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EVAPORATION AND PLANT HABITATS.

BY. DR. BURTON EDWARD LIVINGSTON.

In a previous paper* attention has been called to the fact that, since the evaporating power of the air to a great extent controls the rate of water loss from plants, this climatic factor plays a prime role in inhibiting the growth of many forms in arid regions. It was shown that a number of plants fail to develop normally during the dry season at Tucson, Arizona, although the soil in which they are rooted is kept approximately at its optimum water content. The purpose of the present paper is to call attention to the fact that the evaporating power of the air also appears to play an important part in the determination of the vegetation which can best succeed in different but neighboring habitats in the same region.

The amount of moisture present in the soil is controlled, excepting in these comparatively restricted areas where the subterranean water table is relatively near the surface, by the relation between rainfall and evaporation, and it is doubtless partly through this indirect influence of the latter element, as well as through the direct action of evaporation upon the plant, that this relation is so satisfactory as a differentiator between great centers of plant distribution.** Where

*Livingston, B. E., Evaporation and plant development. *The Plant World*, 10: 269-276, December, 1907.

**On this subject the reader is referred to Transeau, E. N., Climatic centers and centers of plant distribution. *Ann. Report Mich. Acad. Sci.* 7: 73-75, 1905. *Idem*, Forest centers of Eastern America. *Am. Nat.*, 39: 875-889, 1905.

the subterranean water stands at or near the soil surface, the action of evaporation is directly upon the organism, for this element does not then affect soil moisture. But in most localities a high evaporating power of the air is accompanied by a low moisture content of the soil, unless great rainfall provides new moisture to replace that which escapes. In this connection it must be noted that regions of great precipitation are apt to be regions of low evaporation, the low evaporation rate being usually accompanied by high humidity and this being, in a sense, both the cause and the effect of great precipitation.

While the amount of rainfall is a condition effective upon soil moisture, and hence upon vegetation, over large areas, the evaporating power of the air varies greatly within such areas, and contiguous habitats may exhibit marked differences in this power. Two atmometers, one in sunshine and the other in shade, always give very different readings, as would logically be expected from the nature of evaporation. Furthermore, the condition of the soil, nearness to water surfaces, presence or absence of spray in the air and of unusual amounts of saline materials in the soil, exposure to wind, *et cetera*, all influence the evaporating power of the air to a marked degree. To obtain direct evidence as to the relation of the rate of evaporation to the nature of the vegetational cover in nearby habitats, and to obtain information on the value of the atmometer in differentiating such habitats, several tests have been carried out during the recent growing season by a number of observers scattered over the United States. This work was done in connection with another line of inquiry, carried out by the Desert Laboratory in co-operation with the observers, and the results of the comparative tests at the majority of the stations where these were carried on will be brought out by the observers themselves. Data from a set of two atmometers at the Missouri Botanical Garden, and from another set of two at Columbia, Missouri, will be here presented. Also, the writer was able to obtain

some comparative atmometric records from open exposures at Tucson and at three different altitudes in the Santa Catalina mountains, which will likewise be given in this paper.

The atmometer here used was of the form described in the paper on Evaporation and Development, and the instruments were placed as there described, so that they gave readings on the evaporating power of the air at a height of about fifteen centimeters above the soil surface.

The data from the Missouri Botanical Garden were obtained through the kind cooperation of the Director of the Garden and of Mr. Henri Hus. This comparison was planned to exhibit the relation between the evaporating power of the air in the open sunshine and that in the shade of a deciduous coppice. The instrument for sunshine was placed in the midst of an herbaceous garden, and was surrounded by a denuded area with a radius of about two meters. It was not in shade at any time of day, and all vegetation was kept from the area throughout the season. The atmometer for shade conditions stood in a coppice of deciduous shrubs and small trees in the arboretum, and was surrounded by the natural carpet vegetation of the region. It received only a small amount of sunshine during the day.

Two cups were selected with practically the same coefficient of correction and these were placed at St. Louis so that the records began on May 20. These continued in operation for four weeks, till June 17, when an accident resulted in the breaking of the shade instrument. A third cup, the original standardization of which gave practically the same coefficient of correction as the other two, was then sent to St. Louis and there installed for two weeks beside the remaining instrument of the original pair, after which it was placed under the coppice, and the observations continued. In the second standardization we have a test of the evaporation rates of two cups under identical conditions, the one unused except for the original standardization, and the other used for six weeks (two weeks having elapsed between the breaking of

the old cup and the installation of the new one). This test showed that the two cups agreed within about one per cent., an amount of error which is negligible for work of this kind. This shows that six weeks of use, the evaporation of 842 cubic centimeters of water in this instance, had no appreciable effect upon the porous structure of the cup. This is one of several similar tests which lead me to believe that the porous cups here used may be regarded as reliable for an indefinite period of use when only distilled water is passed through them.

This series of observations was continued from July 22 to October 14, a week having been lost between restandardizing the new cup and placing it in the shade exposure. The corrected data, in cubic centimeters, are given in the two following tables, the first of which includes the comparative records up to June 17, and the sunshine records to July 22, and the latter those from July 22 to October 14. In the third line of each table are given the ratios of the rate in sunshine to that in shade for the respective weeks. The march of this ratio shows clearly the effect of leaf development in the early summer and of leaf fall in autumn.

TABLE I.

<i>Week ending.</i>	<i>Sunshine.</i>	<i>Shade.</i>	<i>Ratio.</i>
May 27	220	112	1.9
June 3	62	10	6.2
June 10	142	54	2.6
June 17	143	55	2.6
June 24	141	---	---
July 1	146	---	---
July 8	196	---	---
July 15	188	---	---
July 22	202	---	---

TABLE II.

<i>Week ending.</i>	<i>Sunshine.</i>	<i>Shade.</i>	<i>Ratio.</i>
July 29	211	64	3.2
August 5	194	75	2.6
August 12	203	50	4.0
August 19	163	65	2.5
August 26	140	42	3.3
September 2	195	77	2.5
September 9	160*	72*	2.2*
September 16	160*	72*	2.2*
September 23	198	104	1.8
September 30	180	115	1.6
October 7	114	80	1.4
October 14	160	100	1.6

On June 10th two atmometers were installed at Columbia, Mo., one in a strawberry patch in the open and the other in a shade tent also in the midst of strawberry vines. Readings were taken at approximately weekly intervals until October 9, when the experiment was discontinued on account of frost. For operating these instruments I am indebted to the co-operation of Dr. B. M. Duggar, through whose kindness these comparative data are here presented. The rates are given in Table III, which also includes the ratios of the rates in sunshine to those in shade. The coefficients of correction for these two cups were 0.992 for the one in sunshine, and 0.995 for the one in shade, that is, the observed loss is to be multiplied by the proper coefficient to produce the quantity which would have been lost from the standard cup, had it been used in place of the one actually in operation. As has been stated in the article on Evaporation and Development, coefficients which vary from unity by an amount less than 0.01 are neglected. Therefore the rates given in Table III are those actually observed.

*Calculated from a period of two weeks.

TABLE III.

<i>Period ending.</i>	<i>Sunshine.</i>	<i>Shade.</i>	<i>Ratio.</i>
June 17	105	28	3.75
June 24	80	20	4.00
July 1	84	57*	1.50
July 8	127	50	2.5
July 15	77	26	3.0
July 22	66	40	1.7
July 30	66	50	1.3
August 6	34	20	1.7
August 12	33	37	.9
August 19	20	39	.5
August 26	36	44	.82
September 2	---	---	---
September 9	102	55	1.9
September 16	137	57	2.4
September 23	175	50	3.5
October 2	158	46	3.4
October 9	105	25	4.2

The gradual decrease in the weekly rate during the months of July and August was at least in large part due to growth of the strawberry plants about the instrument, practically covering the cup. These were cut away August 26, after which the rate suddenly increased remarkably. This emphasizes the shade influence of one plant upon the conditions for the growth of others.

At the time of the removal of the strawberry vines surrounding the instrument in the open, some green algae were discovered on the cups, which were therefore both removed to a laboratory room and operated for one week under exactly the same conditions. Both lost the same amount of water during that period. In this case one cup had evaporated 411 cc., while the other had lost 728 cc., and yet there

*The comparatively high rate for this week was at least partly due to an injury to the tent which exposed the instrument for forty-eight hours.

had been no alteration in their relative evaporating powers, another instance illustrating the lasting qualities of the instrument.

It was planned at the outset of the season to obtain records from four different altitudes in the vicinity of Tucson, Arizona. The atmometers were placed at the University of Arizona, altitude 2412 feet, and at three stations in the Santa Catalina Mountains. The lowest of these stood in an opening in an oak chaparral at the extreme lower edge of bull pine, at an altitude of about 6000 feet. The instrument was not shaded from the sun but was shielded from wind action to a considerable extent. Another atmometer stood in a bare gravelly area surrounded by a very open growth of large bull pine trees and small oaks with here and there a thicket of scrub oak, at an altitude of 7500 feet. The third instrument for the mountains was placed in a broad valley surrounded by high hills, in the midst of a dense growth of bull and sugar pine and of Douglas spruce, at an altitude of about 8000 feet. The opening in which the latter instrument stood was only some fifteen meters in diameter and the shade of the neighboring trees and of the surrounding hills cut off the direct rays of the sun for some time at the beginning and end of the day. The Tucson instrument was exposed in the midst of a bare area on the campus of the University of Arizona, with no shade and hardly any vegetation within many meters. An attempt was made to place all of the instruments so that they would be subjected to the same conditions as would have to be borne by the average seedling developing in the respective localities.

The mountain atmometers were placed on May 12 and 16 and were read May 31 and June 1. Other readings were taken at later dates, but the porous cups became clogged through the use of water which proved to be impure, and the later records are not trustworthy. The Tucson instrument was installed May 27, and was read weekly thereafter, through the kindness of Dr. W. B. McCallum. The first

week of its period of operation corresponded approximately to the last week of the first mountain period. A general idea of the relation of the evaporating power of the air at these four stations can be obtained by comparing the weekly rates of loss from the mountain instruments with the evaporation from the Tucson instrument for the first week after its installation. The corrected results are given in Table IV. The rates are in cubic centimeters and of course are to be considered simply as numbers representing the relative evaporation rates at the four stations at this time of the year. In the third column of the table are given the relative numbers, the rate at Tucson being considered as unity.

TABLE IV.

<i>Altitude.</i>	<i>Weekly rate, cc.</i>	<i>Relative rate.</i>
2412 feet.	289	1.00
6000 feet.	238	0.82
7500 feet.	147	0.51
8000 feet.	133	0.46

From these data it appears that, during the last week in May the evaporating power of the air at the four stations considerably decreased toward the higher altitudes. The week which these records are taken to represent marked the first vigorous spring growth in the highest altitude given. The average weekly rates for the period from May 13 to June 3, at Orono, Maine, Burlington, Vt., and Raleigh, N. C., were 123 cc., 112 cc., and 126 cc., respectively, by instruments exactly similar to those here used. The vegetation about the highest instrument in the Santa Catalina Mountains possesses the same ecological characters as that in the vicinity of Orono and Burlington, the higher levels of the Santa Catalinas being occupied by pine, spruce, maple, alder, elder, cornel, brake, columbine, violet, etc. Furthermore, plants in Maine and Vermont were in about the same condition as those at our upper station at this time of year. The season at Raleigh was of course much farther advanced at this time, so that

the similar evaporation rate obtained from that station is not to be taken as denoting the same sort of conditions for plant activity. The length of the Raleigh season is similar to that of our second station, but its average evaporation rate is much lower, and its vegetation, of course, quite different.

The data above presented show clearly that the evaporating power of the air furnishes a very valuable criterion for the comparison of the conditions of different plant habitats, and, taken with the physiological observations brought out in the paper on Evaporation and Development, they must be considered as at least exceedingly strong evidence that this power of the air is a controlling factor in the determination of the plant population of any habitat. In such studies as these evaporation is more valuable than temperature, humidity, or wind velocity, for the reason that it includes the effects of all these greatly varying factors, as far as they influence water loss from plants, and it is very difficult if not impossible at present to combine data of these elements so as to exhibit their combined influences. The atmometer here used is exceedingly simple, inexpensive, and easily operated, which can hardly be said of recording instruments for temperature, humidity, and wind velocity. For studies of this sort recording instruments are quite essential, and this atmometer automatically records the effect of the conditions without any delicate and complex mechanical device. Also, since the effect of external conditions upon organisms is a function of duration as well as of intensity, i. e., of rate, it is necessary to integrate or sum the varying partial effects of these conditions as time elapses. While the anemograph both records and integrates, the integration of curves of humidity and temperature is a difficult and only partially satisfactory process, and one not performed by the instruments. But the integration of the evaporation data recorded by the atmometer is a part of the very working of the instrument itself. Finally, evaporation acts directly upon the plant, while the three elements upon which it depends act only indirectly.

Desert Laboratory,
Tucson, Arizona.

ON THE ELECTRIC RESISTANCE OF SOLUTIONS OF SALT PLANTS AND SOLUTIONS OF ALKALI SOILS.

BY DR. W. A. CANNON.

A salt spot of considerable extent lies in the bottoms of the Santa Cruz river along the old Fort Yuma road, near the city of Tucson. The spot is rather sharply set off from the surrounding bottom land by the character of its soil and by that of its vegetation although the physiography of the two are apparently not unlike. The natural vegetal covering of the non-alkali lands in the vicinity of the salt spot is made up very largely of such trees and shrubs as *Prosopis velutina*, *Acacia Greggii*, *Bigelovia Hartwegii*, *Koeberlinia spinosa*, *Suaeda suffrutescens*, *Zizyphus lycioides* and *Atriplex canescens*. Among the plants which are typical of the salt spot itself are *Atriplex canescens*, *A. polycarpa*, *A. elegans*, *A. Nuttallii* and *Suaeda suffrutescens*. In addition to these there are along the washes which traverse the spot *Bigelovia* and *Prosopis*. Generally speaking the plants which are characteristic of the salt spot have a well marked zonal arrangement. As one enters the "alkali" area he encounters *A. canescens* with which are to be found also *Prosopis* and *Bigelovia*. This zone is referred to in this paper as the *canescens* zone. As one passes through this zone on his way to the center of the spot he encounters *A. polycarpa* with which are species of *Lycium* and *Suaeda* also, but non-salt plants as *Prosopis* are confined to the washes. This is the *polycarpa* zone. Still nearer the center of the area *A. Nuttallii* is met and with it *A. elegans* also occurs and dwarfed specimens of *Suaeda*. At the very center of the salt spot there are no plants.

The soil of the river bottoms is mainly adobe; that of the salt spot is a fine sandy loam. Analyses of soil by the Bureau of Soils, U. S. Department of Agriculture, taken from the upper foot at the center of the spot, are as follows: *Mechanical analysis*,—clay, 33.3 per cent.; silt, 21.5 per

cent.; very fine sand, 17.0 per cent.; fine sand, 23.5 per cent.; medium sand, 2.6 per cent.; coarse sand, 2.0 per cent.; fine gravel, 0.1 per cent. *Chemical analysis*,— MgSO_4 , 3.38 per cent.; Na_2SO_4 , 70.78 per cent.; KCl , 4.42 per cent.; NaHCO_3 , 15.48 per cent. During the dry seasons the salts appear at the center of the spot as a rather heavy white encrustation.

The salts are not uniformly distributed in the soil. The total soluble salts in the first foot, as determined by electric resistance tests made by the Bureau of Soils, was 1.72 per cent; in the second foot, 1.0 per cent; and in the third foot, 1.3 per cent. Tests made by the writer with a standardized instrument of the type used by the Bureau of Soils* showed that the salts are also unequally distributed horizontally. Following is given the resistances in ohms of soil solutions from the three plant zones of the salt spot; the results were not reduced to per centages.

Canescens zone, 1350 ohms.

Polycarpa zone, 350 ohms.

Nuttallii zone, 31 ohms.

The field tests show thus that the salts are most abundant in the *Nuttallii* zone and least abundant in the *canescens* zone, and that they are intermediate in amount in the intermediate zone. A detailed study of the spot would show a secondary variation in the distribution of salts as the washes which run through it are flooded with each considerable rain and carry away the salts of the banks to so great an extent that as noted above plants which are not highly salt resistant may grow along them.

With the establishment of certain definite relations between the relative amount of salts in the soil and the kind of halophytes occurring on them it seemed desirable to study somewhat more closely the nature of the plants so sharply contrasted with one another. Analyses of salt loving plants show that chlorine is present in large quantities as the follow-

*Kindly loaned by Prof. R. H. Forbes, Arizona Experiment Station.

indicates: *Armeria maritima*, 26.68 per cent. (only 1.99 per cent. in the root); *Aster tripolium*, leaves, 43.00 per cent., stem, 47.08 per cent.; flowers, 19.10 per cent.; *Chenopodium maritimum*, 44.06 per cent., stem, 47.08 per cent.* Analyses of the ash of *Atriplex canescens*, *A. polycarpa*, and *A. Nuttallii*, made under the direction of Prof. W. J. Gies, Columbia University, show that they contain 9.15 per cent., 9.11 per cent., and 24.56 per cent. chlorine respectively. The material for these analyses was selected from the zones of the salt spot of which each species is typical. The Atriplexes, therefore, are to be classed among the most marked halophytes although *A. canescens*, and perhaps *A. Polycarpa* as well, grow also in soils that are apparently free from alkali. A comparison of the results in Wolff's tables of plant analyses shows that there is a very general agreement between the relative amounts of such elements as calcium, magnesium, chlorine, potassium and sodium in the soil and in the plant growing on the soil, although the selective power of plants may materially alter this relation. And Nathansohn has shown** that the HCl content of the expressed sap of the sea weed *Codium tomentosum* is the same as in the surrounding medium and that Cl ions will diffuse into or out of the cells of the plant in accordance with the greater or less density of the ions in the surrounding medium. These facts suggested the possibility that the salt plants which occupied areas, the soils of which are unlike as to salts, might in themselves vary as to salt content. To test the relative abundance of salts in the three types of halophytes of the salt spot solutions were made in a uniform manner which were tested for electric resistance with the apparatus used on the soil solutions. The following table summarizes a typical series of experiments.

*Schimper, Plant Geography, Eng. Trans., p. 88, cites Wolff's "Ash Tables."

**Referred to in Role of diffusion and osmotic pressure in plants, Livingston, p. 78.

Canescens zone.*Atriplex Canescens* 65 ohms.*Bigelovia Hartwegii* 115 ohms.*Prosopis velutina* 650 ohms.*Polycarpa* zone.*Atriplex polycarpa* 35 ohms.*Suaeda suffrutescens* 25 ohms.*Bigelovia Hartwegii** 110 ohms.*Prosopis velutina** 70 ohms.*Lycium Andersonii* (?) 67 ohms.*Nuttallii* zone.*Atriplex Nuttallii* 25 ohms.*Suaeda suffrutescens* 42 ohms.*Prosopis velutina* 280 ohms.

The averages of five series of tests made during the summer of 1905 are as follows: *A. canescens*, 41 ohms; *A. polycarpa*, 23.9 ohms; *A. Nuttallii*, 18.2 ohms. As generally speaking the electric resistance is inversely as the salt content *A. canescens* would from these tests have least salts (electrolytes) and *A. Nuttallii* would be richest in salts, while *A. polycarpa* would hold an intermediate position in this regard. In other words the variation of salts in the soil finds its counterpart in the variation of salts in salt plants typical of the soil. The results thus derived by the use of the bridge was apparently substantiated by the results of analytic work of Prof. Gies who found the total soluble matter in the ash of the three species to be as follows: *A. canescens*, 62.27 per cent.; *A. polycarpa*, 66.99 per cent.; *A. Nuttallii*, 79.20 per cent.

Unsuccessful attempts were made to express plant juices in sufficient quantities for the electric resistance tests so that dilution would not be necessary. Could this have been done and could the juices also have been frozen, the relative resistances taken together with the freezing points would have

** *Bigelovia* and *Prosopis* were growing along one of the washes that traverse the salt spot.

given data on the relative osmotic values of the plants. And one series of experiments, which were repeated, on the freezing point of *solutions* of the three types of halophytes (not on pure juices) gave results fully in accord with the results with the bridge on the same material. A further difficulty in relating the results as given above to the possible osmotic strengths of the plant solutions lies in the nature of the parts of the plants brought under observation,—only leaves and young stems were selected for study. To be of value for the purpose of comparing the osmotic relations of plant and soil it would be necessary to study the absorbing system of the plant, which was impracticable. It remains therefore for future work, which may perhaps best be cultures, to determine the osmotic relations of these salt plants.

From the experience outlined in this note of testing the resistances of plant and soil solutions suggestions for the wider use of the method have very naturally suggested themselves. In general the method appears to be applicable wherever salt plants (or animals inhabiting saline waters) are being studied in relation to the habitat. This would be not only the forms of the sea and of brackish waters but those used in cultures as well. And it may be suggested that many such forms would be so rich in juices that the study could be pursued without their dilution so that direct comparison with the resistance of the medium in which the forms occur could be had, which would be of great value as well as great interest.

Desert Laboratory.

SOME OBSERVATIONS ON ARIZONA FUNGI.

BY J. C. BLUMER.

It appears to be the impression of botanists who are unacquainted with the floral possibilities of the desert that a collector need not be prepared for preserving fungi as such would not be found in abundance in a country so dry and hot. While to a limited extent this is probably true of the most

arid portions of the territory during the dry seasons at least, it certainly cannot be said of the mountain regions, particularly of the Chiricahuas with which I am familiar, since without giving particular attention to the fungi, I collected during the months of July and August, 1907, nearly 100 species, and in one hour in August over 59 distinct forms. The validity of this thesis will appear from the following general account of some of the most striking of the fungi whose names unfortunately cannot be given as the plants have not as yet been completely worked up.

Mildews were found on *Solidago* and *Anoda*; a bluish-gray fungus was found abundantly on *Erodium cicutarium*. In one case a shelf-fungus was found attached to a living and apparently healthy specimen of the semi-desert *Quercus emoryi*. On another oak (*Q. arizonica*) a remarkable globular mass was observed which was over 15 cm. in length. The surface of this fungus was made up of cylindrical projections with colored tips; it was whitish beneath and toward the upper surface brown, while a pinkish color ranged midway. The same species of oak, and *Q. gambelii* also, each supported two more fungi belonging to the *Polyporus* type. In addition to the above shelf fungi were found also on living specimens of the ash (*Fraxinus* ?), sycamore (*Platanus Wrightii*), locust (*Robinia neo-mexicana*), and manzanita (*Arctostaphylos pungens*).

A rust was very conspicuous in the fall of 1906 on a small rosaceous shrub, and a fungus, black when mature, infested a species of *Cylindropuntia*. Leaf spots appeared on many plants of which none were more interesting than those which infested the leaves of the mistletoe (*Phoradendron flavescens*) which was parasitic on the walnut (*Juglans rupestris*). The case of a mushroom parasitic on another mushroom, to which attention has been called recently by Professor Atkinson,* was looked for but was not found. In all 23

*A mushroom parasitic on another mushroom, *Plant World*, 10: 121, 1907.

species of fungi were observed on their living hosts although no especial search was made for them.

The gill-bearing fungi ranged from half a centimeter to 15 cm. in size. Mostly beautifully symmetrical, some were also irregularly scalloped; and some were funnel-shaped with the gills on the outside. Another prominent group was the type with spongy or perforated fruiting surfaces. These also varied greatly in size and shape; some grew on soil and some on dead organic matter. The largest of this group measured 23 by 25 cm. and was supported by a stalk 10 cm. high.

A third extensive group were the shelf fungi which usually grew on dead wood or other organic matter, and also on soil rich in humus. They varied in shape from the nearly round oak parasites to those composed of thin and wavy lobes which overlapped one another. The latter type were often of great size. One, the largest fungus encountered during the collecting season, measured 27 by 33 cm. It was on the ground and enveloped the bases of several green plants. A common form of *Polyporus* on pine stumps sometimes reaches nearly this diameter.

The puff-balls were also represented by several species, among which was a form intermediate between the gill-bearers and *Lycoperdon*. It was white in color and shaped like an orange. It grew beneath an evergreen oak. There was a great variety of striking forms not only among the *Basidiomycetes* but also among the lower orders. These were of all colors and many had distinct and characteristic odors.

Several interesting relations were observed between species of fungi and the habitat, such as among young soil forms stems like corkscrews were often present by whose movements (resulting from variation in water content) the way could be forced through the soil. There was a close relation between the dryness and warmth of the habitat and the form and size of the fungus and the duration of life.

In general, though there may have been exceptions, the

larger the size (usually), the firmer the texture, the more closely attached to the substratum, the drier and warmer the habitat, the more able were they to withstand changes of light, moisture and temperature, the longer was their life.

From the foregoing brief account of some of the more striking facts observed it will be seen at once that the environmental conditions must be very like those which obtain in other regions where fungi are a prominent feature of the flora. These were daily copious showers, a temperature which ranges from 15 deg. to 21 deg. C., long periods of cloudy days; in addition to these conditions should be added an altitude of 8000 feet, a pine forest, and a humous soil.

COLOR VARIATION IN SOME COLORADO FLOWERS.

BY FRANCIS RAMALEY.

It is well known that almost any colored flower may have a white variety or there may be at least individual plants with white flowers. Other color variations are by no means so common. During the past season the writer has noticed a few somewhat striking departures from the usual color in the flowers of some common Colorado species. In fact, the species are so common—being represented by thousands of individuals which one might see in an hour's walk—that it is strange that there should be some variants without a great many.

Aragallus lamberti (Pursh) Greene. This very abundant species is represented in both the plains and mountain floras and is perhaps as common as any other plant with brightly colored flowers in the whole of northern Colorado. The flowers are regularly a reddish-purple but they turn to blue in drying. Sometimes they are yellowish. On July 31 of this year I observed near Ward, Boulder County, a single plant otherwise normal but with flowers of a distinctly greenish robin's-egg color. The plant was well covered with flowers and was very conspicuous even from a distance.

Lupinus decumbens Torr. Flowers of this species are regularly a pale blue or bluish-purple. I have seen two or

three plants near Boulder with flowers distinctly pink and no suggestion of purple.

Glycyrrhiza lepidota Nutt. This well-known species is described in all the manuals as having flowers which are yellowish-white. At various points, especially a few miles north of Boulder and also near Red Mountain in Larimer County, Colo., the flowers are regularly bluish-purple. In fact there are so many specimens with the bluish flowers that I have hesitated to include this in my list. The color has doubtless been noticed by many observers and has perhaps been recorded but I have not seen any mention of it.

Achillea lanulosa Nutt. This very common plant of the plains and mountain regions seldom shows the purplish color in the ray flowers often noted in the eastern *A. millefolium*. In fact I have never seen until this season any heads with this color variation. A number of plants with purple rays were seen at Ward, Boulder County. My colleague, Professor T. D. A. Cockerell tells me that this variant is sometimes seen in New Mexico.

Sedum stenopetalum Pursh. Here is another very common species found everywhere in the foothill districts. The flowers are described as "yellow" or "bright yellow" in all the manuals. During the past summer I noticed about half-a-dozen plants in which the veins of the petals were bright red and the tips and margins were also bright red. This gave the flower clusters a most unusual and striking appearance.—University of Colorado, Boulder, Colo.

A COSTLY BULB.

In the early part of the seventeenth century the cultivation of the tulip was the chief occupation and delight of the Dutch florists. This oriental flower had but recently made its appearance in Holland, and the beauty and novelty of the tulips raised by the Hollanders soon attracted the admiration of all Europe, for no people as a nation are fonder of flowers or take greater pleasure in their culture than the

Dutch. It became the fashion in Paris for women to wear these flowers as corsage bouquets, and the gift of a cluster of Dutch tulips was much thought of.

The desire to possess new varieties caused a steady increase in the price of bulbs and flowers. Rich men and enthusiastic gardeners were willing to pay extravagant prices for rare specimens. Certain kinds became more highly prized than others by reason of their scarcity or because of some unusual feature. The *Semper Augustus* was then thought to be the most valuable of all the tulips ever produced, and is famous to this day for the prices it commanded. According to the writers of that time, it was a flower of the most exquisite beauty. The petals were pure white marked with dark red stripes of various shades, giving them the effect of watered silk. Here and there was a suggestion of delicate blue tinging the edges of the petals.

A wealthy merchant of Amsterdam once paid the enormous sum of fifteen hundred dollars for a bulb of this wondrous flower. A few days later a vessel arrived in port from the East, bringing him a valuable consignment of merchandise. One of the sailors hastened to tell him of its arrival, and as a reward the merchant presented him with a smoked herring. On the merchant's desk lay the *Semper Augustus* bulb, which next spring was to gladden his heart with its lovely blossom. Not being satisfied with the merchant's generosity, the sailor picked up the bulb, thinking it was an onion. In a few minutes the merchant discovered his loss. A hue and cry was raised for the sailor, who meanwhile had retired to a quiet spot on the wharf, where he was found sitting on a coil of rope eating his lunch of herring and "onion". He had no idea that the meal he had just eaten was so costly, for he had indeed thought the onion a very poor one; it had no taste. The enraged merchant had the poor sailor put into prison, where he remained many months.

Southey, in his *Colloquies on Society*, speaks of tulip bulbs as being at one time in Holland as costly as jewels or

pictures, and adds that it was one of those contagious insanities to which all communities are at times subject. In his critical essay on this book Macauley questions whether it be a greater proof of insanity in men to set a high value on rare tulips than to set the same value on rare stones, which are neither more useful nor more beautiful.—I. A. Glasse.

Introduction to Botany, by W. C. Stevens, published by D. C. Heath and Co.—The multiplicity of elementary textbooks in scientific subjects does not necessarily represent any marked progress of the science, new ideas, or successful methods in presenting the subject. When the book is by a scientist of repute one looks mostly for two things, first, the material, *i. e.*, the topics selected for presentation, for an elementary text, or even a text of any kind such a small part of the whole subject can be presented, and, second, the manner of presentation. In the book before us the style is clear and concise, and quite readable. The book is a mixture of laboratory manual and descriptive text, though it is sometimes difficult to determine whether the directions are for student or teacher. A good discussion of the topic usually follows the laboratory directions, though it is to be observed that these directions decrease as the book progresses until finally they are omitted entirely. The book savors strongly of ecology and is strikingly lacking in both morphology and physiology, particularly the former. On the whole the author deals with the higher plants, and with the parts of them that are most familiar. Seeds and seedlings, structure and function of roots, stems and leaves, growth and movements, modified parts, dispersal of fruits and seeds, adaptation to environment, plants of different regions, are the main topics of discussion. A very brief survey of the fungi and algae, mosses (omitting entirely any mention of liverworts) and ferns is taken, and an extensive study of the flower is presented.—W. B. M.

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THE PEDIGREE-CULTURE: ITS AIMS AND METHODS.

BY DR. GEORGE HARRISON SHULL.

There is a considerable body of data now on record of every degree of accuracy and inaccuracy, upon which it is easy to base discussions of variation, heredity, evolution and kindred topics if one has a good imagination and a sufficient faith in the correctness of data he may wish to cite, and the eternal verity of certain hypotheses which were put forward by some ancient seer, or which hang like a cloud on the horizon of his own inner consciousness. The experimentalist lacks this sublime faith. His motto is "*Ignoramus, in hoc signo laboremus.*" Investigation shows him that the available data are scanty indeed that are not written all over with question-marks, which would need to be exchanged for exclamation-points in order to justify the strenuous attitude taken by some writers who seem to assume that these momentous questions are either already settled or are beyond the legitimate sphere of experimentation.

From some of these contemnners of experimentation comes the criticism that the distinctive feature of the pedigree-culture method is isolation unlike anything which commonly occurs in nature, and that the results can have valid application only to those rare situations in which similar isolation is found in nature. This statement of the case is quite erroneous and may prove misleading to those not familiar with the scope of the pedigree-method. The distinctive feature of the pedigree-culture method is not isolation, but perfect knowledge of ancestry to a certain number of terms. No

student of "Genetics", as Professor Bateson aptly calls the new science which has the pedigree-method as its peculiar instrument, has limited his attention to the study of "pure-line" cultures and it is recognized by all such students that the usefulness of the pedigree-method has not been exhausted until every possible combination has been made with the material in hand. Thus, in the case of the most gigantic piece of pedigree-culture work that has yet been done, namely, the studies upon the *Oenotheras* by de Vries, followed on a large scale by MacDougal and many others, there is abundant published data showing the result of crossing each of the several mutants with their parent and with each other. It may be granted that the cause of science will be advanced by the repetition of some of this work for the sake of confirmation or of further analysis, but the points to be made here are that *these combinations have been made* and that the making of such combinations is a prominent feature of all pedigree-culture studies that have been made or are being made. It is needless to urge that in nature no other than the possible combinations exist, and that therefore when with respect to any species or group the full scope of the pedigree-method has been utilized we have the fundamental data upon which alone can be based any proper conception of what goes on in nature, and that the data so found when properly confirmed by repetition are applicable to all nature in which the particular species or group in question is involved.

The pedigree-method with the resultant perfect knowledge of ancestry has given to biological science the two most illuminating suggestions which have come to it from any source in many years, namely Mendelian inheritance, and the Mutation theory, with their common postulate, the existence of unit-characters and character-bearing units or determinants. It is not known how universal these great truths are but evidence is accumulating daily to show that they are truly of wide-spread and fundamental value. The only test of the extent of their applicability is the one by which they were discovered, namely, the pedigree-method.

To attain to perfect knowledge of ancestry, the ideal toward which the pedigree-culturist strives, many precautions are necessary, and as the fundamental character of the problems of genetics is bound to attract increasing numbers of investigators, it is thought that the writer's experience in the conduct of experiments involving the pedigree-breeding of plants at the Station for Experimental Evolution may be of use to others who have occasion to take up such work, and this is the author's motive in presenting the following account of methods used.

Perfect knowledge is a high ideal and not absolutely attainable, because some sources of error can not be eliminated. This is due principally to the fact that they are of the nature of catastrophes which can not be foreseen; but if reasonable care is taken the results will usually be so decisive as to leave no doubt of their correctness, and in cases of doubt, where it may be assumed that some unexpected and unknown error has crept in, the cultures may be and should be repeated. The same accident is not likely to occur a second time to the same pedigree. A pedigree with a question-mark in it is usually no better and often very much worse than no pedigree, and any material whose pedigree is in doubt should be at once eliminated, or if the material is rare and valuable in itself, it should be treated as any other unknown material, namely, assigned a distinct pedigree-number or other designation which gives no suggestion of relationship to other known material. Cultures grown from such questionable material may indicate its relationship by the characters presented, but knowledge of this relationship rests purely on inference, and that inference is just as trustworthy in itself when no hint of probable derivation has been noted as when the record indicates a probable but doubtful origin.

The most important factor in the elimination of errors is a high ideal in this regard on the part of all those who have anything to do with the cultures. Mind and senses

must be on the alert for every possible source of contamination of pollen and of seed, or of mistaken labels and records. Briefly the method I am following at the Station for Experimental Evolution is as follows:

Seeds of individual plants, whose pollination has been controlled when that has been practicable, are collected and to the seeds of each such individual a pedigree-number is assigned, giving reference to a record, or description of parent and parentage. These are sown in earthen pans of sterilized soil at such time that the offspring may be expected to reach maturity at the close of the first season. For most biennials and perennials this planting must be done before the 1st of March, while the annuals are not sown until about the 1st of May or later. When sufficiently developed, the young seedlings are set in 3-inch pots, each of which receives a wooden label bearing the pedigree-number of the mother plant. As a rule no selections are made in removing from the seedpan. If all are not to be reset the requisite number is secured by taking all consecutively, beginning at one side of the pan, until the desired number has been removed, after which the contents of the pan are dumped.

At the proper season such as are destined for out-of-door culture are reset to the garden, and those which are to be used for indoor culture may or may not be reset to larger pots, as the needs of each particular case requires. A label once attached to a plant accompanies it throughout its life, and is copied on the seed packet which contains its seeds. The chance of error is slight after the plants have been potted singly and each has received its appropriate label. The most critical points in the technique are the control of fertilization, the sowing of the seeds, and care of the seedpans. These matters, together with the question of labels and records, may be discussed with profit to others engaged in pedigree work, or contemplating taking it up.

In regard to the control of fertilization the general method consists (a) in preventing self-fertilization or cross-

fertilization as may be required by the particular experiment in hand, (b) the protection of the pollen to be used from mixture with pollen from unknown sources, (c) the conveyance of the pollen to the stigma of the desired mother-plant, and (d) the continued protection of the latter until the possibility of its accepting pollen from any other source is past. In carrying out this program each individual case will require special refinements of technique which can only be derived by a study of the peculiarities of the particular species under experimentation. For example, plants which, like *Helianthus annuus* and all dioecious species, cannot fertilize themselves, will not require the removal of the stamens, and this fact greatly simplifies the technique in some cases which would otherwise present peculiar difficulty.

When self-fertilization is possible, the conduct of "pure-line" experiments is peculiarly easy, the only important requirement being the exclusion of foreign pollen. On the other hand, if the experiment with self-fertilizing material requires that a cross be made, the stamens must be removed from the plant chosen as the mother, before the anthers dehisce, the time at which this must be done being different in different plants, according to the relative precocity of stamens and pistils. In *Oenothera* it is necessary to castrate 24 hours in advance of anthesis, while in strongly proterogynous flowers the anthers may be removed at the time of pollination. Both the stigmas and the pollen must be protected from insect visits and other agencies for the carriage of pollen. For this purpose the best method is to enclose the entire inflorescence (or in some instances the single flowers) in bags of paraffin paper. These are made in various sizes to order by A. G. Stursberg, New York City. I have found the most generally useful sizes to be: 8 in. long x 3 in. wide, 10x4, 10x7 $\frac{3}{4}$, 15x4, 17 $\frac{1}{2}$ x6, 19 $\frac{1}{2}$ x15 $\frac{1}{2}$, and 20x9 $\frac{3}{4}$. These may be attached to the plants in various ways. I have used ordinary white cotton pack-thread, and raffia, but have found the nurseryman's 3 $\frac{1}{2}$ -inch wired tree

labels by all odds the most convenient, as they can be attached or detached almost instantly, and the label may bear a statement of the particular cross that is being made. In order to secure a satisfactory quantity of seed it is nearly always necessary to repeat the process of pollination several times between the same two parents, and the inscriptions on the tags prevent errors in the way of mixed parentages, even when a large number of sister plants are being operated upon simultaneously.

For removal of the anthers I find most useful a pair of forceps, different sizes and styles being best suited to different cases. A needle-pointed forceps serves for both dissection of the buds and removal of the anthers in the case of *Bursa*, but in most flowers of larger size a broader pointed forceps is preferable. I prefer to remove the anthers with as little injury to adjacent parts as possible, but when the perianth is thick and elastic so as not to allow easy access to the stamens on merely opening the buds, as is the case in *Verbascum*, it is desirable to remove it. For this purpose a small curved dissecting scissors is very satisfactory.

For the conveyance of the pollen to the chosen stigma the method must again be varied to meet the requirements of the material. In the majority of cases it is most satisfactory to detach the flower which is to supply the pollen and carry it in such a way that nothing comes in contact with the anthers, which are then touched directly to the stigma. The pollen-plant is uncovered only long enough to allow the removal of the flower to be used, and the pistil plant only long enough to receive the pollen, the bag being replaced in both cases as quickly and carefully as possible. In certain cases this ideal technique is impossible. For example, in *Helianthus annuus* the method of handling individual flowers is not feasible, and here it is my custom to use camel's-hair brushes. One brush is used for each pair of heads to be crossed. When not in use this brush is kept securely enclosed in an ordinary seed-bag which bears the pedigree-number of

the two plants upon which it has been used. The pollen from the head of one of the plants is brushed into one Syracuse watch-glass and instantly covered with another. In this way it is carried to the other plant of the pair and applied carefully to the circle of receptive stigmas. Then the pollen is brushed from this plant into the same dish and returned to the first member of the pair, to be brushed upon its receptive stigmas. The dishes are then deposited in a jar of 90 or 95 per cent alcohol, where they remain until the following day, when they are washed and used again. The same brush is used day after day on the same pair of plants until the operation is completed, when it, too, is consigned to the alcohol jar. In this case, as in all others, the protecting bags are removed from each plant no longer than is absolutely necessary for the performance of each operation.

In controlling the pollination of Indian corn still another method is used. Both ears and tassels are enclosed in paraffin paper bags before the external appearance of stigmas and anthers. Pollen is produced in great quantity which collects in the bag enclosing the tassel. This bag is removed from any plant desired and carried to the plant to be pollinated. The silks are uncovered and immediately sifted over with the pollen, which trickles from a small hole torn in one corner of the bag. The silks are then quickly re-covered and the pollen bag is returned to the plant from which it was taken, to be used again the next day or the second day after in a repetition of the process. This work is usually done in the afternoon when almost no pollen is falling from other plants, in order that the entrance of foreign pollen during the momentary uncovering of the silks, shall be reduced to a minimum.

Probably the most potent sources of error in these various methods consists: (a) In the possible fertilization by foreign pollen which has been scattered upon the foliage of the plant and so enclosed within the bag; and (b) its introduction by the wind or insects in the brief period during

which the bag is removed for the purpose of castration and pollination. The audacity of some of the short-tongued bees has necessitated the sacrifice of a number of flowers after the greatest care had been used in controlling their pollination. Experience has taught in all those cases in which the entrance of foreign pollen would make itself plainly apparent in the result, that the precautions taken gives essentially perfect control of pollination.

(To be continued.)

PROBLEMS OF THE DESERT.*

BY DR. D. T. MACDOUGAL.

If an adequate pluviographic map of the world were compiled it would reveal the fact that a considerable area in each of the great land-divisions receive a much smaller amount of rainfall than the possible evaporation, and is therefore inevitably arid, the low precipitation in the main being due to orographic features, intervention of wind barriers, and lack of conditions necessary for condensation and other relations to the prevailing winds.

These regions, amounting together to the area of an American continent, are distributed from the equator to high temperate latitudes, and are for the most part central or interior in their localization, although the stated conditions obtain to a marked degree in some coastal tracts, especially in western America.

The essential and resultant features of deserts include undeveloped drainage, activity of wind erosion, great diurnal variation in temperatures, low relative humidity, and nearly humus-free soils, with comparatively small vertical increase in the proportion of soil-moisture. Landscapes of this character are readily recognizable by the xerophytic aspect of the vegetation inhabiting them.

* Given before the Washington Academy of Sciences, Jan. 7, 1908.

Some general anatomical arrangements peculiar to the vegetation of deserts are found to be widely prevalent regardless of the phylogeny of the forms bearing them, while the conditions enumerated are so sharply defined, and their variations so well marked, that the relation of the plant in the desert to its environment take on the definiteness of an equation, offering a solution of some of the main problems of biological science, most of the factors set forth being as capable of estimation, and their action of measurement as the components of an experiment in the laboratory.

From the great group of inquiries solvable by such equations those pertaining to the origination of the structures, qualities and capacities of organisms and the mechanism of of the distributional movements by which the resultant forms have reached their present positions may be selected for illustration.

The enclosed basins of Nevada, Utah, Central Asia and Australia are examples of deserts in which much of the flora must have come into existence in its present aspect within comparatively recent periods. Furthermore the geological record in some of these regions may be taken to have been read with such fair completeness that the length of the periods and the amplitude of the oscillations may be taken as at least tentatively established and some general ideas upon the relations between climatological variation and the evolutionary changes in organisms may be formulated.

If an entire cycle had passed under the eye of a trained observer, the opportunities for analysis would have doubtless yielded the exact information by which some of our problems might have been solved. These lengthened investigations being beyond us, our next recourse is to a duplication of the conditions within time-limits during which continuous investigation may be carried on. Such duplication is offered by the re-formation and un-making of the lakes in the desert basins of the Colorado delta, with of course an enormous con-

densation of the time-factor, about the action of which in the major movements of plants we know but little.

Let us consider the Salton experiment, for it comes quite as opportunely to the workers of the Desert Laboratory, as if we had ourselves poured the two and a half cubic miles of water into the Colorado desert covering 500 square miles of its surface and totally exterminating the plants living there. The moist zone which comes from the saturated soil fringing the shore of the new lake now offers suitable conditions for



Figure 1. Map showing position and form of Salton sea in southern California.

certain halophytes instead of the xerophytes previously found there while the still broader fringe of humid air favors the growth of species not hitherto native to the basin. To this region there travel the seeds of plants of a half dozen states by the waters of the inpouring Colorado, wafted upon the wind currents and taken here and there by animals, so that theoretically and actually thousands of species of plants are testing these new habitat conditions as suitable places for residence.

The mere checker-board arrangement of habitats, now or ten years hence, after the usual descriptive methods would reveal nothing of unusual importance in these areas. An analysis of the conditions, of quite another character has been projected with a fair hope of making an adequate interpretation of some of the major distributional movements. This will necessitate the closest observation in following the recession of shore lines five to a dozen miles down the slopes of the basin, during the next decade, making numerous measurements and estimations of the nature and rapidity of the movements and responses of the plants. The recession may not be expected to take place at a constant rate, as a result of which important changes in the mechanical composition of the emerged soil will be made. The waves will excavate terraces, forming dunes and barriers, sorting material which it leaves behind in separate layers, each being suitable for different formations of plants. As the result of such previous action, the ancient beach lines thousands of years old are still marked by the bands of vegetation which follow them. So much for the purely physical disturbances. Still another condition is to be taken into account. The basin into which the water was poured is a patchwork bowl, with irregular portions of its wall variously charged with salts as a result of long-continued leaching action. The water has, however, uniformly saturated the surface layer of soil of the submerged area with a solution containing about one-third of one per cent of salts. It is to be seen, therefore, that the plants growing on the unsubmerged portion of an area containing one per cent of alkali will not immediately follow down the beach in the reoccupation of the ground left bare by the receding waters. Before this is done slow weathering and incessant capillary action must operate to the re-differentiation of the areas as to soil salts, and many occupations and re-occupations of the surface by other forms must intervene.

It is in this period that the action of the major factors upon living things in the formation of deserts will be simulated. Hundreds of species will be subject to unusual conditions of soil-moisture, saline solutions and seasonal change, while variations of temperature of wide amplitude and other possible inciting causes may exert the strongest influence upon their ontogenetic development. The question as to the nature of possible adaptations of plants under such conditions presents itself at once.

It seems to be tacitly assumed by the majority of writers for example, that the changes undergone by a mesophytic species when grown in an arid situation are of such nature as to fit the individual better for living under the drier conditions. This does not always follow. The form assumed by a shoot in a dry atmosphere is the result of growth conditions established by the balance among the absorbing organs, the conducting stems, and the transpiratory surfaces. In many cases the restricted surfaces are an advantage, but it is an advantage offset by the fact that the root-systems have equally failed to accomplish the normal amount of growth so that the general relations of the individual remains as before.

Over a hundred species of seed plants were grown in complete darkness and under faint illuminations in the experiments upon etiolation which were completed three years ago. The absence of light was seen to set in action morphogenic processes of the most diverse character in various species, in some of which the stems were enormously thickened, in others elongated, with various unusual and totally useless development of tissues, in which the supply of reserve food was used. Illustration of these non-adaptive responses might be multiplied indefinitely.

Not only are the direct ontogenetic and morphogenetic responses of plants to environmental forces not necessarily of an adaptive character, but it is impossible to derive some of the most highly specialized and heritable structures with the supposedly causal conditions which they meet. Spines

and spiculae do lessen the ravages of grazing animals upon cacti to some extent, but these structures are undoubtedly a direct and accumulated response to aridity, or poverty of available water, and in a dozen species the deterioration of leaves and branches has been carried so much farther that we have that many spineless or nearly unarmed forms in American deserts, which suffer variously or not at all from animals. Illustrations of a similar nature might be multiplied indefinitely.

The entire matter rests upon the fact that when a stimulus consisting of a change in intensity of temperature, light, soil-solutions, or humidity is brought to bear upon a plant it responds as a living machine, while at the same time the direct effect of the external force upon the parts of the machine or its processes may materially modify their properties, or cause radical alterations in the processes themselves.

Another aspect of the subject remains to be considered. In addition to the direct physiological, somatic response of a plant expressed in its roots, stems or leaves, it is to be borne in mind that many of the agencies which cause these variations also act directly upon the germ-plasm, which give a direct response, and not of an adaptive nature.

By the controlled application of climatic factors, Tower has been able to induce the appearance of strains of beetles which diverged from the parental type in one main character with correlated variability in others, which crossed readily with the parent and might be swamped by it. By the application of reagents to the reproductive elements of seed-plants I have been able to cause the appearance of new forms of plants which diverge from the parent in several qualities, which do not readily cross with the parent, and the newly acquired characters are irreversible so far as the tests of three generations may be taken as conclusive. Results of a similar nature have been obtained by Gager with the use of radium preparations. The direct effects might consist in a

modification of the relative speed or precession of the various processes in the gamete, or of the activities of the chain of enzymes, or of some disturbances of the delicate balance among the ions in the protoplasm. Still beyond these, stimulative responses or reactions may occur, which would find their ultimate expression in deviations in external form of the progeny of an individual subjected to the unusual agencies in question. Changes of the same nature may well be induced by many conditions to which plants are naturally subject, the survival of the resultant forms being solely a matter of possible interbreeding and habital selection.

A stream takes its rise near the alpine plantation of the Desert Laboratory, and flows out on the desert a few miles away, and a mile lower down. Doubtless hundreds and thousands of seeds are carried to the lowlands each year. Some of these develop into individuals which carry out reproduction. This is usually done in the native habitat, at actual temperatures of the tissues not above 60° or 70° F. Down below, spore formation, reduction divisions and fertilization may ensue in temperatures 40 or 50 degrees higher, a difference capable of being endured by the shoots of some plants now being tested, and which might well cause irreversible developmental changes. Other factors of the environment may operate in a similar manner.

Perhaps the most evident opportunity offered to the student of the desert is that which promises a solution of some of the problems of distribution, particularly with respect to plants. The absence of crowding of the elements in a formation, the definiteness of the factors affecting movements, and the great areas which can be brought under observation in which no disturbances by cultivation have arisen, lay the problem out with the clearness of a diagram. A day spent in sectioning the vegetation of a mesa and an adjoining mountain slope will show that the conventionalized comments customarily given in descriptive works as to centers of distribution, place or origin, significance of density of popula-

tion, etc., etc., are mechanical, inadequate and often fallacious.

No simple illustration of the distributional movements, or the travels of a plant may be brought to bear, but if we were to place a few dozen drops of water, tinged with various shades of color to represent a score of species on a large board held level, some portions of which are polished and some left rough, then imitate changes such as elevation and depression, advance and retreat of the ice by tilting irregularly in several directions, the drops would be seen to run about, sink, merge, and vary in their grouping, sometimes leaving a path of small globules behind, now joining to form wet extended bodies or drop off the margin in a manner highly suggestive of the actual fate of living organisms. Some movements will be re-traceable to a limited extent and some will not.

Practically every investigation of the vegetation of the desert touches upon the questions of water relations at some point. Firstly, the comparatively uniform vertical distribution of moisture in the soil is accompanied by a fairly superficial development of root-systems, the penetration for anchorage being very slight in conjunction with the absence of tall forms. Not only are the roots of desert plants of great lateral development, but they show a stratification in habit: the roots of contiguous individuals occupying certain layers within 4 inches of the surface, others of the next 6 inches, while few go beyond the next foot in any density of branching. The conducting systems of these forms are often taxed to the utmost, while the real conception of any practical use in dealing with the physiology of desert plants is that of the relation between the possible rate of evaporation from a water surface and the actual rate from a leaf, which is known as relative transpiration.

A large number of species representing a score of the great natural orders of plants exhibit a strongly developed capacity for the storage and retention of surplus water in

specially developed tissues of the stem, root, branches or leaves. While this feature is exhibited most abundantly by plants of arid regions in which the rainfall comes within a brief season, yet it is also found in a goodly number in moist tropical jungles, and caution in designating it as a direct adaptation seems desirable. Before much progress may be made in the analysis of the storage function it will be necessary to come at the chemical mechanisms by which it is made possible, together with an analysis of the environmental forces which incite or inhibit it. Twelve or thirteen hundred species of cacti exhibit this capacity in varying degrees, and it is this chiefly which gives them their possibilities as a valuable forage plant. Our optimism as to the possible benefits must not blind us to the fact that nine-tenths of the body of a cactus is water and that no more than a reasonable fraction of the amount present in the surface layer of soil two or three feet in depth can be taken up and made available for the construction of stems, or accumulated in storage organs. It is, however, one of the most promising investigations yet undertaken looking toward the possible utilization of native desert plants.

Primarily but indirectly the comparative struggle for existence in the desert is one for water, not among plants so keenly as between animals and plants. If it were possible to exclude certain birds and mammals from the domain of the Desert Laboratory, the included square mile would soon become a dense forest of sahuaro (*Cereus giganteus*). In addition to the enormous consumption of seeds, almost all of the seedlings, which have a swollen hypocotyl, are appropriated by animals since these present about the only available supply of water in the dry after-summer during which they come into activity. So keen is the quest for this material that the few dozens that may be grown in the experimental greenhouses of the Desert Laboratory are inevitably destroyed unless guarded. The actual balance then is not between the sahuaro and other plants, but between this great

cactus and certain animals, with the water supply as the indirect crucial factor.

In addition to questions toward which the desert offers the main and nearly sole opportunity for solution, there are problems which require a consideration of the entire range of climatal conditions for their complete understanding. An illustration of this is to be found in the functional action of stomata.

Scores of contributions have been written from studies upon stomata made in humid, tropical and temperate climates upon the finely automatic action of these organs in regulatory response to transpiration conditions. The researches at the Desert Laboratory, especially those by Lloyd, show that stomata open, widen and close in response to other stimuli than those arising from the humidity or aridity of the air and the turgidity or flaccidity of the leaf, making necessary and possible a new version of the physiology of foliar organs. A similar case is presented by the relations of the plant to soil-moisture.

It needs but a moment's consideration to show that our psychycological attitude toward such matters is faulty. The features of plant life of the moist, temperate and tropical climates are subconsciously assumed to be normal, typical or average, while forms native to other regions are regarded as adaptational and abnormal.

In a broader view however, clothing of stems in wax, hairs or spines are no more adaptations than bark, leaf-excision and scores of other devices. Without doubt had these structures been first described by the botanists of a desert-dwelling people much would have been made of them as adaptive non-typical formations. The activities of the student of desert forms will indubitably contribute to a rearrangement of perspective upon many phases of morphology and physiology.

The attack of problems under untried conditions implies efficient weapons, new methods of attack and so far as the

facts will allow, strategy to attain new view-points from which to plan the contest. Toward this idea we owe much to the original suggestions upon the matter formulated by Mr. F. V. Coville, which led to the establishment of the Desert Laboratory.

The actual material equipment in all of the researches of the nature which have been considered are centered at the Desert Laboratory at Tucson, Arizona, at an altitude of 2700 feet in 32° N. This modest workshop, which has nearly reached its full expansion as to buildings and major equipment is the center of the activities of all the workers concerned, and its facilities are planned to meet their needs alone.

The unusual advantages presented by its environment need not be enlarged upon at this time, being simple and apparent. The amplitude of the range of conditions embraced in the adjunct experimental opportunities are worth a moment's attention. The domain of the Laboratory itself embraces over a square mile of desert mesa and volcanic mountain range of nearly a thousand feet. Near it is an irrigated experimental area in the alluvial bottoms of the Santa Cruz river. The shoulder of the nearby Santa Catalina mountains offers suitable conditions for the arid plantation at 6000 feet, while in a higher moist valley the mountain station lies at 8000 feet. About 40 species of plants are now variously introduced, distributed and exchanged among these places, with the result that some exist through a vertical mile and in a series of climates varying from humid sub-alpine to arid sub-tropical, with what marked somatic responses I must leave to a future communication for description. In these plantations the experiments are limited to a few species, are carefully restricted as to scope, and are more or less under cultivation, careful measurement of the environic features being possible and necessary.

The seven surveyed areas around the Salton Sea will be the scene of purely observational work with such measurements of conditions as may be possible. All of these investi-

gations are designed to formulate simple equations of measurable factors, from which the origination, somatic response, physiological action, trajectory in evolutionary change, and distributional movements of living forms may be adequately considered and advanced interpretations of these major activities of living forms made possible.

Desert Laboratory.

A METHOD FOR CONTROLLING PLANT MOISTURE.

The method here described was developed for maintaining constant moisture conditions in the soil of pots, boxes or other containers in which plants are grown. It is useful in all cases where plants are to be grown without daily attention to watering, and is the only method I have discovered which avoids the puddling of the surface soil and the great fluctuations in general water content incident to periodical watering.

A porous clay cup* of the form used in evaporation measurement (as described in Publication No. 50 of the Carnegie Institution and in the *Plant World* for December, 1907) is filled with water and stoppered with a perforated rubber stopper bearing a tube of glass and rubber or of lead, which connects with a reservoir of water. The tube must be filled with water when the stopper is inserted, so as to avoid any air bubbles between the reservoir and the cup. The reservoir may be a large bottle or any suitable container. A convenient length of tube is about a meter, although this is varied according to conditions. The cup is buried in the soil of the pot or box in which the plants are to be grown. In the case of a pot it is convenient to place it erect in the center, when a larger vessel contains the soil the cup may be placed horizontally and at a depth of five to twenty centimeters.

* The porous clay cups here used may be obtained by addressing Dr. Forrest Shreve, John Hopkins University, Baltimore, Md.

After the apparatus is in position, the seeds or plants are placed in the usual way, and will continue to grow normally as long as the reservoir is not emptied. The soil draws water from the cup and this is kept filled from the reservoir. If water is removed from the soil, by evaporation or by plant absorption, more is simultaneously withdrawn from the cup, so that the moisture condition of the soil mass is kept practically constant. The moisture condition at which the soil is in capillary equilibrium with the cup is determined by the resistance offered to the removal of water from the latter, and this depends upon the distance which the supply must be lifted from the reservoir. If it is desired to maintain the soil in a state of saturation the reservoir is placed somewhat above the level of the cup. By lowering the reservoir a drier soil may be maintained, but if the reservoir is too low the soil will be too dry for plant growth. With different soils the level of the reservoir will vary for the same moisture content; for ordinary potting soils and ordinary plants it is well to have the reservoir thirty or forty centimeters below the cup. The level needed is easily determined for any soil by direct experiment. The reservoir should be of rather large horizontal section in order to prevent the great fluctuations between fillings. Where no attention is to be given the cultures for weeks at a time a constant level device may be attached to the latter and this connected with the water supply pipe so that filling is unnecessary. The same reservoir will serve for any number of pots.—Burton Edward Livingston.

Gibraltar, Jan. 20, 1908.

A PERENNIAL DODDER.

Whether a plant maintains its functions in a state during the winter season from which it may succeed to renewed activity upon the advent of spring depends in many cases upon individual peculiarities. Some run their course in a few months, and rarely exhibit the power of persistence, even

where the climatic conditions are favorable. Many herbaceous plants are of this sort. Some, however, when the temperatures do not go too low, persist and continue to grow year by year and become true perennials. The castor-oil plant is a very good example and a well known one. In favorable regions this plant attains the proportions of a tree. At Torreón, Coahuila, trees twenty-five feet in height occur. In the higher altitudes of Northern Zacatecas, where light frosts occur, the castor-oil is often killed back to some extent.

Here, however, may be observed an analogous behavior on the part of a species of dodder (*Cuscuta*) which grows on various woody shrubs, among which are the guayule, *Parthenium argentatum*, the hojasen, a broad leaved composite, and others. During the growing season the dodder affects the new growths of the host plant in the usual fashion, withering away from the now woody growths of the previous year. Developing luxuriantly, it spreads after the manner of its kind, from branch to branch, often smothering its host, and causing a partial or total failure to make growth in many instances. It flowers and bears its fruit well into the autumn, and often may be found with a few flowers even in January. In any event, it seldom dies out, but, growing up among the upper leaves of its supporting twig, it becomes attached to these also, and, forming an irregular, more or less compact clump, it passes a period of quiescence, during which growth almost or quite ceases. In this condition the stems of the dodder are reduced in size, especially those which extend away from the support of the host. Its whole aspect bespeaks its lessened activity. But it is there ready for the warmer weather of spring, and the advent of the rain which will stimulate both it and its host. This fact accounts for the rapid appearance of the parasite on the woody parts of the plant, into the tissues of which it is unable to penetrate. It is in fact never found on the older growth excepting near the new growth, where it has not yet succumbed to the secondary thickening which destroys its hold on the host.—Francis E. Lloyd.

FIRST CROSSES BREEDING TRUE.

Hybrids of the first generation which breed true offer many difficulties in the theoretical explanation of hybridization and hence most writers on genetics are disposed to doubt their existence. Bateson in a recent summary says: "Of the considerable number of examples in which this phenomenon has been alleged to occur, few have been satisfactorily observed on a large scale. The evidence is not in my opinion in any case so cogent that it can be accepted without hesitation, and if genuine examples exist, they must be exceedingly rare, for I do not know of any that have been attested by adequate evidence since the modern methods of genetic research have been in use."

In addition to the earlier evidence presented by DeVries on this matter he has recently published an article in which he gives results in which all of the hybrids of the evening primrose in the *Onagra* group were found to be fixed and constant. (Bot. Gazette, Dec., 1907.) A fixed hybrid was produced by the writer by pollinating *O. Lamarckiana* by *O. cruciata* several years ago, and this form has been found constant in the several generations which have since been grown under cultivation.—D. T. McD.

The influence of pollination on the respiratory activity of the gynaeceum, by Jean White, is the subject of an important paper in *Annals of Botany*, for October, 1907. The author studied species of *Eucalyptus*, *Fuchsia*, *Pelargonium*, *Digitalis*, *Begonia*, *Tecoma*, *Tropaeolum*, *Cheiranthus*, *Antirrhinum*, *Anemone*, *Lilium*, *Canna* and *Agapanthus*. Among the important results the writer found that the pollinated material of *Pelargonium* produced 5.8 times as much carbon-dioxide as the unpollinated, *Cheiranthus* 2.0 times as much, and *Antirrhium* 2.6 times as much by weight. Throughout the experiments with few exceptions, which were mainly among the Monocotyledons, the respiratory activity of the

pollinated exceed that of the unpollinated gynaeciums. In one pair of experiments with *Canna* very curiously the opposite was true, that is, the unpollinated material respired more actively than the pollinated.—W. A. C.

Miss F. N. Magowan, of the University of California, presents the results of some experiments upon the toxic effects of soil salts, in the *Botanical Gazette* for January, 1908, in which it was found that sodium, potassium, magnesium, and calcium are poisonous. The methods used were based upon determinations of the highest concentration of each salt in which the plant could live for extended periods.

Dr. B. E. Livingston, member of the staff of the Desert Laboratory, Carnegie Institution of Washington, has been given leave of absence for one year, which will be spent in the prosecution of research work in soil physics and moisture relations in plants in European laboratories.

The MacMillan Co. announce the early publication of a work on the physiology of plant production by B. M. Duggar, and a work on bacteria in relation to agriculture.

Mr. A. K. Chittenden has been appointed assistant in the U. S. Forest Service to investigate the White Mountains and Apalachian Mountains with a view toward the proposed national park.

A symposium on the species conception was held by the Botanical Society of America, at Chicago on January 1st, 1908. The taxonomic aspects of the subject were presented by Drs. C. E. Bessey and N. L. Britton; the physiologic aspects by Drs. J. C. Arthur and D. T. MacDougal; and the ecologic aspects by Drs. H. C. Cowles and F. C. Clements. The full text of the papers will be printed together in *Science* at an early date.

Mr. H. R. Fulton, Plant Pathologist of the Louisiana Experiment Station, has resigned and will on January first, assume the duties of Assistant Professor of Botany in the Pennsylvania State College of Agriculture.

Mr. H. R. Fulton, who recently resigned his position as Plant Pathologist in the Louisiana Experiment Station at Baton Rouge, entered upon his duties as Assistant Professor of Botany in the Pennsylvania State College on February 1st.

Dr. H. L. Shantz, of the University of Missouri, has been appointed Professor of Botany in the State University of Louisiana in place of Dr. F. H. Billings, who recently resigned.

Prof. J. W. Harshberger has undertaken a comparative morphologic and physiologic study of the clovers, and wishes to receive dried and preserved material from any source. Postage will be refunded, or express paid on material sent to him at the University of Pennsylvania, Philadelphia, Penn.

A scientific movement on a great scale has been inaugurated in Hawaii, which is called the Pacific Scientific Institution, with Honolulu as headquarters. Wm. A. Bryan is president and Gov. Frear is chairman of the Board of Trustees. It is planned to explore the Pacific, to make collections, and to study the ethnology, anthropology, zoology, botany, geology, climatology and oceanography of this vast region. A botanical garden of acclimatization will be installed in Hawaii. The work is said to involve an initial expenditure of \$400,000.00; and as much more annually for the fifteen years for which the explorations are planned.

Trinity College, Dublin, has just completed a two-storied building for the School of Botany. The upper story consists of a large microscope room and auditorium for students, where about sixty are accommodated, a preparation room and an assistant's room, and in the lower story are a laboratory for microscopic research, a general physiological laboratory, a library, the professor's laboratory, a chemical laboratory, and a greenhouse. As it stands, the new School of Botany in Trinity College is said to rank with the best in the British Isles.

THE PLANT WORLD

A Magazine of General Botany

MARCH, 1908

ASPECTS OF NEW ENGLAND LICHENS.

BY R. HEBER HOWE, JUNIOR.

This curious bit from Thoreau's "Winter" I cannot refrain from quoting at the outset of these papers, as it is such an appreciative sketch of a delightful study—"when I see the sulphur lichens on the rails, brightening with the moisture, I feel like studying them again as a relisher and tonic, to make life go down and digest well, as we use pepper and vinegar and salads. They are a sort of winter green which we gather and assimilate with our eyes. That's the true use of the study of lichens. I expect thus the lichenist will have the keenest relish for Nature in her every day mood and dress. He will have the appetite of the worm that never dies, of the grub. To study lichens is to get a taste of earth and health, to go gnawing the rails and rocks. This product of the bark is the essence of all tonics. The lichenist extracts nutriment from the very crust of the earth. A taste for this study is an evidence of titanic health, a rare earthiness. It makes not so much blood as soil of life. It fits a man to deal with the barrenest and rockiest experience. A little moisture, a fog, or rain, or melted snow makes his wilderness to blossom like the rose." . . . "A lichenist fattens when others starve. His poverty never fails . . . There is no such collyrium or salve for sore eyes as these brightening lichens on a moist day. Go bathe and screen your eyes with them in the softened light of the woods."

It is my purpose to prepare, what may be termed, some meager monographical papers on the more conspicuous

lichens common to New England; not because I feel myself possessed of any great knowledge of the plants, outside the necessary results of the observance of them for a period of years, but because I feel that no presentation of them, clear at all, has ever been attempted so far as I am aware.

I have tried to treat the present species, and shall the future, in a scientific manner, presenting not so much the observations of others, but the conclusions reached from my own study of them. Lichens have been mainly studied from a purely scientific and systematic point of view, i. e., the naming of new forms, the determination of their exact place in Nature; the former at least, after all, of little importance. Little has been done or at least written, of their life histories—and though much of what I write is known to others, it is nowhere, so far as I know set down.

Thoreau, when he philosophized thus, spoke for many of us—"I knock the back of my hand against a rock, and as I smooth back the skin I find myself prepared to study lichens there" "I have almost a slight, dry headache as the result of this observation. How to observe is how to behave." "To crown, all lichens which are so thin are described in the *dry* state, as they are most commonly, not most truly seen. They are indeed, *dryly* described."

PARMELIA CAPERATA (L.) Ach.

Wrinkled Parmelia. "Stone Crottles."

Synonymy: *Lichen caperatus*, Linn, sp. Pl. 1:1147.

1753.

Parmelia caperata, Ach. Meth. Lich. Pt. 11. 216. 1803.

Imbricaria caperata (L.) De Cand, Fl, Fl. Gall. 84. 1806.

Description: (See Fig. 1.) The thallus varies in specimens from strong membranaceous to coriaceous, sometimes reaching on rock substata a diameter of fourteen inches. Rock examples develop the thinner, membranaceous thallus, tree examples the coriaceous. In young specimens the entire thallus *above* is pale green to sulphurous, occasion-

ally darkening centrally; old examples, especially those on rock substata, have only the periphery pale green, darkening centrally to often a very dark green or almost black. The lobes of the thallus are large, imbricate, and rounded, sublobed, and round-toothed. The central portion of the thallus is irregularly folded and wrinkled, the crest of the folds, in fully developed examples, from partially to entirely sorediate, finally reaching a conglomerate crust of usually, white or pale green soredia, rarely darkened to the color of the thallus. The remainder of the thallus is often sparingly sprinkled with soredia as well.

Beneath the thallus is black, slightly wrinkled, and largely covered, except at the periphery, which is dark-glossy brown, with a black, often crustose nap of rhizoids. The central, white medullary layer is sometimes exposed in removing specimens from the substratum.

The *apothecia* (see Fig. 2) are rare, (the ratio of plants bearing them, exceeding small) generally poorly developed, and often easily over-looked, occurring as a rule in rock growing examples. They appear first as seemingly circularly arranged soredia, not more than a millimeter in diameter, between the folds of the thallus, the dark brown epithecium hardly visible. The largest apothecium of New England examples that I have examined is eight millimeters* in diameter. They are generally irregular in shape, finally grouped, with sorediate or isidoid, inturned margins, which are finally destroyed, exposing plainly the chestnut-brown epithecium. The *spores* are simple, without color, elliptical, measuring from 15 to 25 by 7-10 micromillimeters.

Substratum. *Parmelia caperata* occurs on living coniferous and deciduous growths, rocks, walls, unpainted buildings, fences, rarely primarily on decaying vegetation. It is a tree loving species, occurring commonly on fences, and

* Specimen from Vermont, collected by C. G. Pringle, Sprague Herbarium, Boston Society Natural History. (See Fig. 2.)

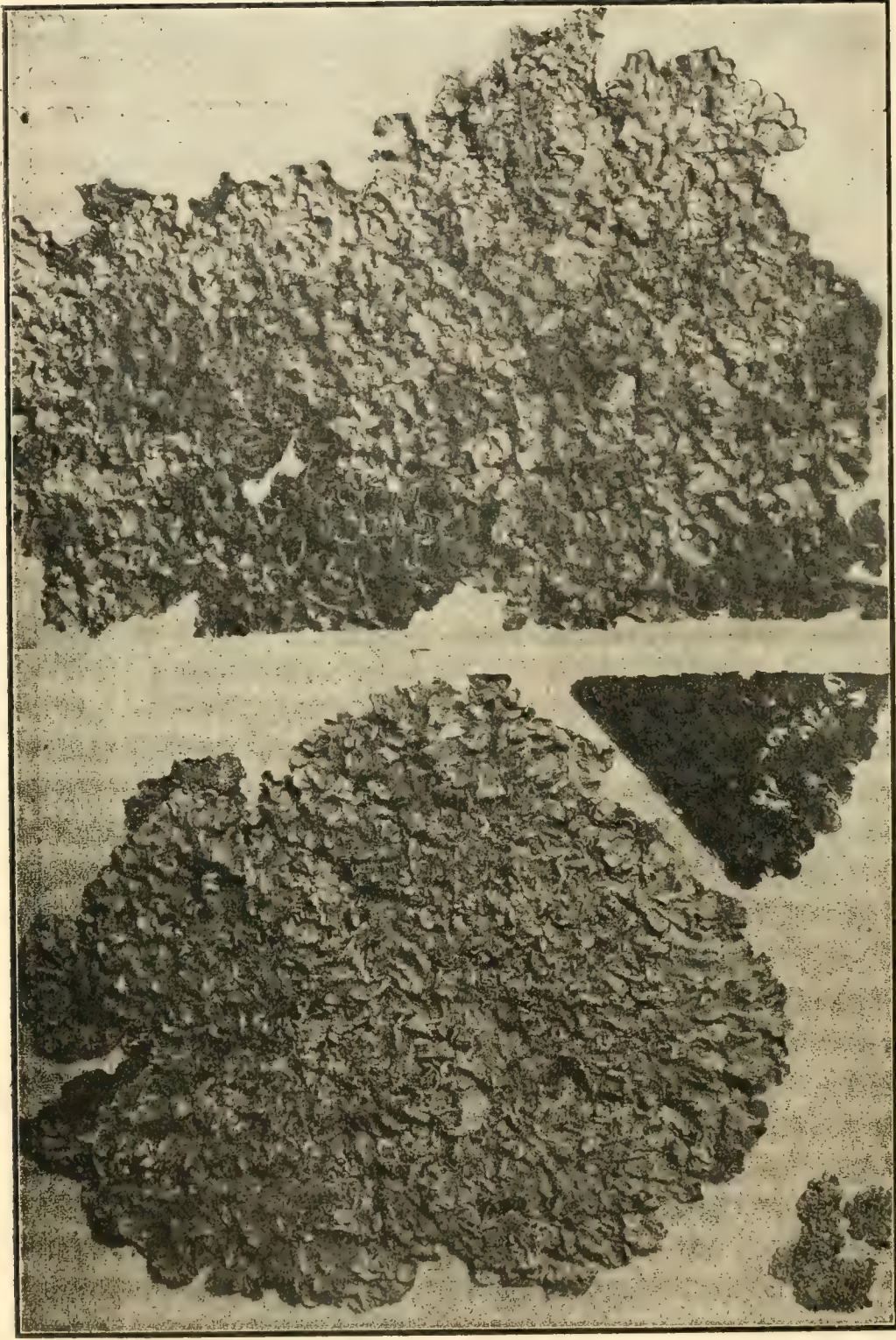


FIGURE 1.—*Permelia caperata*. Typical plant from apple-tree (*Pyrus*) substratum, showing lobation and soredia. The lower figure to the right shows underneath side of thallus with exposed white of thallus, and the figure to the left shows apothecia of common development.

FIGURE 2.—Specimen showing large and fully developed apothecia—a very rare condition.

buildings, and not uncommonly on rocks. The trees of the New England apple orchards are conspicuously decorated with them.

Distribution: Common throughout New England in the Austral and Transition zones, occurring perhaps less commonly in the Canadian, and absent, so far as I have observed, in the Hudsonian as represented in these States. Its presence, on other than tree substrata, seems due, however, to dissemination from tree-plants as in tree-less regions, i. e., above timber line, the lichen does not occur, except accidentally. The distribution of tree-living species to varied substrata beneath, is commonly met with in many species.

Life History: Of all the many and varied species of lichens that are common to New England, there is perhaps no one so conspicuous as the present species, due to three reasons: first its widespread abundance throughout the zones, secondly its large size, and thirdly its fresh green color. From the degenerate and struggling examples of the city environs,* to the perfect and fresh specimens of the primeval forest, it has a certain constancy of character that makes it easily recognizable, and known to all who pay the least attention to their natural surroundings. Yet it teaches the scientific spirit of careful observance, so varied often is its habit, owing mainly to the character of substratum, and the position of growth. For example, a specimen growing on a rock, or on the comparatively smooth and dark colored bark of the young White Pine (*Pinus strobus* L.) or Paper Birch (*Betula papyrifera* Marsh) not only develops into a nearly perfect, circular mat of green, the thallus lobes and structure symmetrical and normal, but it is also set off by its dark or light background so that all its beauty is exhibited in clear relief. (See Fig. 3.)

"The round, greenish-yellow lichens on the white-pines loom through the mist like shields whose devices you would fain read."

* Due to the presence of sulphur dioxide in the atmosphere.

An example started no doubt as favorably on the rough and grooved gray bark of the White Ash (*Fraxinus americana* Linn) for example, develops into a broken disintegrated specimen lacking symmetry, and its true character of growth is nearly obliterated by the unevenness of the substratum.



FIGURE 3.—Typical plant, showing a younger one growing over the center of the first. Maple (*Acer*) substratum.

(See Fig. 4.) Again on a vegetable substratum this lichen never grows in company with *Parmelia conspersa* (Ehrh.) Ach., a species with which it is often superficially confused. Whereas when it grows on a rock it is often accompanied by the above named species, and the separation is at once made difficult. Then still again *Parmelia caperata* rarely fruits,

and in my experience, rock growing examples are as a rule the ones that develop apothecia, and a confusion with the somewhat like colored apothecia of *Parmelia conspersa* is therefore likely to be made. If *Parmelia caperata* fruited commonly throughout the northern portion of its range—it might suggest that in this latitude the colder rock substratum, as compared with the warmer vegetable, had the effect to equalize latitude.



FIGURE 4.—A disintegrated specimen, lacking symmetry on account of its rough bark substratum (*Fraxinus*.)

Another distracting feature in the ready determination of this species, is not only due, as I have suggested, to the character of the surface of the substratum, nor to its vegetable or mineral character, but to the position of the plant's growth. The coriaceous thallus often shows the effect of gravity. If the attachment of the Lichen is discontinuous or weak, it shows the tendency, when growing in a vertical

position on the face of a ledge, for example, may be such as to allow the shredding out of the thallus into vertical rugae, which at once changes the whole character of its appearance. This condition is helped, no doubt, by water running downward over its surface.

"There is a low mist in the woods. It is a good day to study lichens" "The lichens look rather bright today when they are bright and expanded is it not a sign of a thaw or a rain?" The majority of lichens are

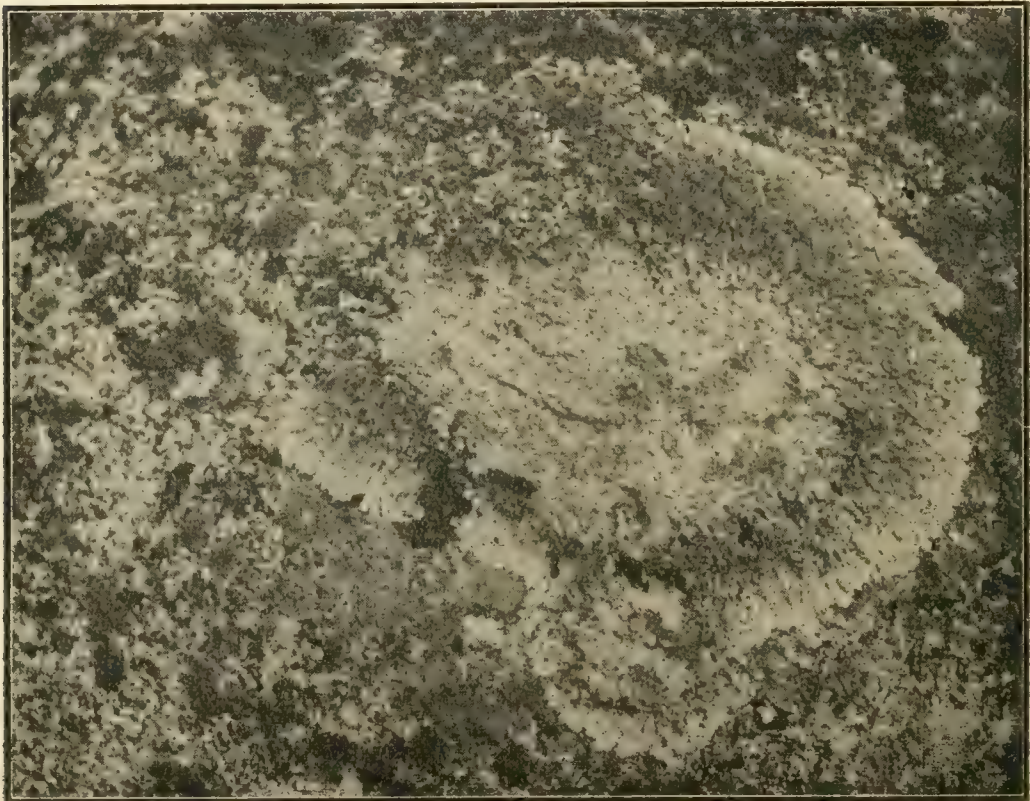


FIGURE 5.—A large rock specimen, showing loss of central portions and peripheral ring. Note on the left a sloughed portion showing black under side of thallus.

much changed by the condition of the weather—a dry or rainy day works a great change. The present species, however, is only slightly brightened by wet weather. This is no doubt explained by the fact that the green of the chlorophyll is always evident in this lichen's color, whereas in many it is only during rainy weather that the alga symbiont is evident.

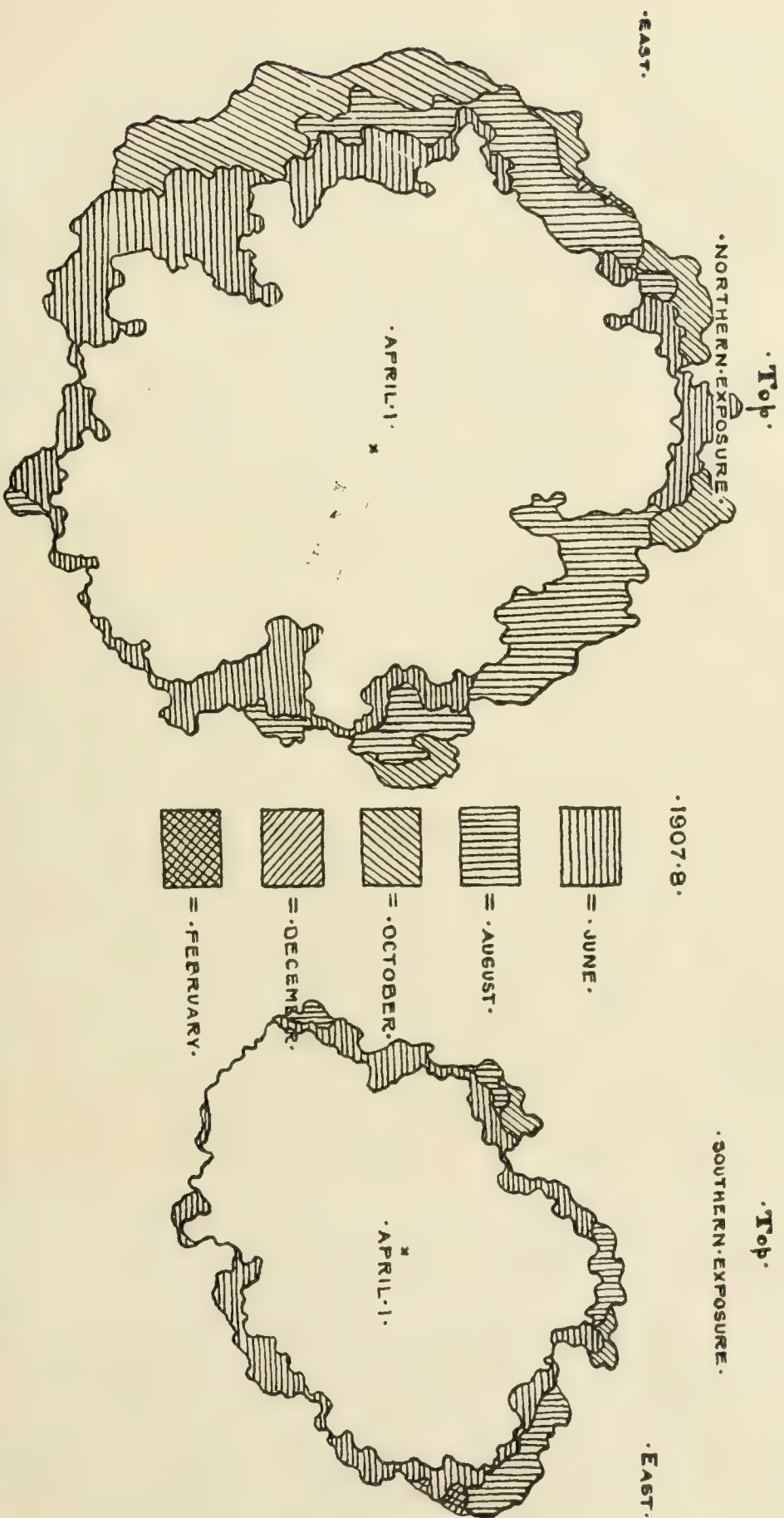


FIGURE 6.—Monthly growth of *Parmelia* on apple and pear. For further explanation see text.

The effect of weathering is, also, an important factor in the appearance of lichens, hardly less so than wear on the plumage of birds. *Parmelia caperata* loses with wear the outer green cortical layer, and the white modulla is so exposed that white becomes almost the predominating color, the green remaining only in the concavities of the furrowed thallus which have been protected from wear. Another effect of age is noticed in the rock growing examples. The central portions turn to a dark, and dingy green, finally dying out, and leaving but a peripheral border, suggesting *Parmelia centrifuga* (L.) Ach. (See Fig. 5.) Within the open interior, and even in the center of the thallus often spring new plants which develop, until a rosette formed of concentric plants is established. (See Fig. 3.)

Lichens have been termed by Ruskin the "eternal tapisseries of the hills," the very antipodes of the ephemeral butterfly—but very little has been done toward determining the actual life time of lichen plants or the rate of growth. The reason for this has been no doubt their very longevity, and the difficulty attending transplantation. During the past year I have measured the growth monthly of two examples of this species, with the following results, though no doubt substratum, the character of its surface, the exposure, and the climate have much to do with the rapidity of growth. Here in Concord, Massachusetts, on a vegetable substratum of average roughness (*Pyrus*—apple and pear), and in a climate of periodic rainfall, amounting to about forty inches per annum, (maximum, August, 4.12 in.) and with a humidity of 82% (maximum, Autumn), two examples, one with a southern and one with a northern exposure, showed the following outline extent and features of growth. (See Fig. 6.) It will be seen that the greatest growth was accomplished during the months of heaviest rainfall, and not only by the plant with the northern exposure, but on the eastern periphery of this plant. We might learn then, that moisture, and cool shade are most favorable to such foliaceous lichens.

Lastly the specimens of the exsiccata it must be remembered, lose with years of preservation, the intensity of their color, due to the lack of moisture for the alga, until they finally become of a pale and dirty yellowish, and their morphology, alone, makes determination possible.
Concord, Mass.

THE PEDIGREE-CULTURE: ITS AIMS AND METHODS.

BY DR. GEORGE HARRISON SHULL.

(Conclusion.)

The handling of the seeds is the next crisis in the pedigree method. Each seed-bag is labelled at the time the seed is collected, and to make doubly sure of the correctness of the record the wooden label is taken from the seed-bearing plant and enclosed with the seeds until a later date when the pedigree records are being made. The wooden label is then removed and carefully compared with the data on the bag and in the record.

As all garden soil contains numerous viable seeds it is necessary that the soil to be used in the germination of pedigree seeds, shall be freed from all other seeds. For this purpose the autoclav sterilizer has proved very satisfactory. This consists essentially of a steam-tight drum fitted with a thermometer and steam gauge. An inch of water is poured into this drum and the soil is put into it in suitable bailed receptacles made to fit the interior of the sterilizer. When the lid is clamped on, heat is applied to the bottom of the drum until the steam pressure within is raised to 5—15 pounds to the sq. in. and this pressure is sustained for about five hours. If it were necessary this process might be repeated the following day, but experience has shown that few if any seeds can withstand the temperature of 110° C. for 5 hours when in the somewhat moist state in which they are sure to be in the soil. When gas is available the problem of heating

the autoclav needs no other solution. As the Station for Experimental Evolution has no gas, resort was had to an alcohol blast-lamp. At first the autoclav radiated more heat than the lamp could supply, before it reached an adequate temperature, but this was remedied by jacketing the drum with felt herbarium driers.

If an autoclav is not available the soil might be freed from seeds by boiling or baking but in both cases the mechanical condition of the soil is apt to be greatly injured. My experiments were begun without a sterilizer but instead of germinating the seeds in garden soil I used sand from a glacial deposit taken in such manner as to avoid the possibility of contamination with seeds which might have been carried to the surface of the sand by the wind or any other agency. The desired result was attained in this way, as no foreign seedlings appeared, but at the expense of failure to get satisfactory germination in many species for whose early development the mechanical qualities of sand are apparently unsuited.

The care and handling of the sterilized soil present many problems. No permanent supply can be safely kept and all soils should be sterilized from day to day as they are needed. Those who handle the soil must keep their clothing brushed and their hands and nails clean. The soil-bench is carefully swept and covered with clean newspapers before the soil is turned out of the vessels in which it has been sterilized. The sifters and other implements used in handling the sterilized soil, if of a character which makes their perfect cleansing difficult, must never be used for unsterilized soil. I use only square earthen seed-pans 30 cm. at the top, 25 cm. at bottom and 7 cm. deep. These are thoroughly scrubbed before using. Wooden boxes of similar dimensions were used at first, but the difficulty of freeing them from seeds which might remain in the joints led me to discard them after once using. After the seed-pan has been made ready for the sowing of the seeds, it is removed to a safe distance from

the pile of sterilized soil and from other seed-pans and after the seeds are sown, a label is inserted, which bears the same number as that on the seed-packet. Then the pan is set in a shallow vessel of water until it is thoroughly subirrigated, after which it is covered loosely with a clean glass plate and removed to its final place in the propagating house. Only one lot of seeds is handled at a time, and the hands are thoroughly cleaned after completing the sowing of one lot of seeds before opening the seed-bag or handling the pan which is to receive the seeds of another pedigree. All watering of seed-pans is preferably done from below, because the slightest carelessness in throwing a jet of water on a seed-pan might transfer a seed from one pan to an adjoining one. If surface watering becomes at any time advisable, the individual pans should be removed to a safe distance from all others during the operation. In the case of surface-watering it is also necessary to take thought as to the source of water used. If from a protected well, it is all right, but at the Station for Experimental Evolution the propagating house is supplied from a reservoir which receives water from an open stream, and there is no safety in using this water on the seed-pans unless it is first filtered, because many small seeds find their way into the reservoir and might be easily conveyed into the seed-pans by surface watering.

All of the foregoing matters are controlled with comparative ease, but there are sources of error which are much more difficult to manage. The director of the experiments understands the necessary precautions and takes them, and so do his foreman and others regularly engaged about the cultures, but not so the casual visitor. The plumber comes in to repair a pipe. He does not take kindly to a request that he brush the hayseed from his clothing before he enters the propagating house. He is sure they will not shake off while he is at work. Visitors want to see the cultures, and it is disconcerting to them to be asked to keep their fingers out of the seed-pans. I have often wondered what about a

seed-pan seems so attractive to the fingers of the thoughtless. The soil looks so smooth and moist that everybody wants to feel just how soft and how moist it is, never dreaming that every time an unguarded finger passes from one seed-pan to another, a fatal question-mark is put into a pedigree that may have cost several years of patient care, and which may have within it the power to solve some problem of far-reaching scientific importance. At one time I discarded six pedigree seed-pans, because earth was thoughtlessly shaken from the roots of lettuce-plants growing in a box of unsterilized soil near the pedigree cultures, by one who did not at the moment see the importance of being careful. To satisfy myself that there was cause for discarding these pans, one of them was saved and in a few days several native weeds were found germinating. As the pedigree-culture was itself that of a native weed, no plant in the pan could be with certainty held to belong to the pedigree indicated by the label. This episode led to the apparently selfish precaution of keeping the pedigree-cultures under lock and key, admitting no one except when a responsible guide was at hand to guard the seed-pans from thoughtlessness and ignorance; and I would advise the same precaution on the part of every pedigree-culturist who wants to be sure of his pedigrees.

Two other instances of error of similar catastrophic type have occurred, which may prove of interest. My head-gardener and I were greatly surprised at one time to find violet seedlings coming up in a number of Bursa seed-pans and we were at first nonplussed as to their origin until it was observed that the majority of these grew along the farther edges of the pans, thus indicating that they had come from the direction of the walk. Following this clew it was found that a few violets were fruiting in pots under an adjoining bench. Though these fruiting specimens were three feet below the level of the seed-pans and four feet or more to the side, the force with which the capsules dehisced was sufficient to lodge a considerable number of the seeds in the

seed-pans, thus demonstrating the efficiency of the violet's method of dissemination. As none of the cultures then in the seed-pans were violets, no harm was done by this unexpected accession of violet seeds, but it is plain that special precautions would be necessary in the study of the violets by the pedigree method, in order to preclude the possibility of contamination with seeds of unknown parentage.

In times of heavy winds it is usually impossible to close ventilators so tightly or the house in general so hermetically that no dust or other debris carried by the wind can find its way through the crevices. Shortly after such a dust storm two specimens of *Erechtites* and one of *Oxalis* were seen to germinate in pans with which the usual precautions had been taken. As fragments of corn-leaves and of the inflorescences of *Panicum capillare* (?) had been found in the propagating house after the storm, it was natural to surmise that the several seeds which appeared where they did not belong had entered in the same way.

When plans are being laid for the prosecution of pedigree cultures on a fairly comprehensive scale the adoption of some system of labeling and note-keeping which shall be sufficiently complete and yet fairly simple is imperative. As the personal equation of the investigator is always an important factor in the adoption of such a system, I do not present the methods used by me as those which are likely to seem ideal to all people, but there may be some suggestions at least which will be of value to others, either as a good way to do it or the way not to do it.

As the number of pedigrees handled is large, the only feasible system of designating them is one whose chief characteristic is the Arabic numeral. I have developed a system which in different phases uses both the Roman numerals and the letters of the alphabet, but which uses the Arabic numerals alone for the permanent designation, or pedigree-number proper. All Arabic numbers used refer to specific individuals. Roman numerals are used only in the garden to designate the

separate rows of each culture, always beginning with (I) at the label-stake and always counting in the same direction across the garden. Letters of the alphabet always refer to types or classes of plants distinguished by morphological differences sufficiently described in the pedigree-records, and, when practicable, also represented by specimens in the herbarium.

It is so generally necessary to make notes regarding individuals before it can be known whether they will ever be used as progenitors, that it is necessary to assign some temporary designation which may afterwards be replaced by a permanent number when it is decided to use them. For this temporary label I use the Arabic numeral in curves, thus (1), (2), etc. All notes entered in the note book regarding any particular individual refers to it under the number thus assigned. This refers only to pot cultures in which each plant has its own label bearing the pedigree-number of its mother. In the garden, the individual plant is not given a separate label, but is referred to in terms of its location. Thus "III. 13" indicates the thirteenth plant in the third row, counting the row bearing the label-stake as the first.

In the construction of the permanent pedigree-numbers, there are several things to be kept in mind: The tracing of pedigrees through successive generations must be facilitated; connection of each member of the pedigree with the notes regarding its characters, and those of its family must be made as perfect and simple as possible; and numbers must be kept from getting too large, as the likelihood of incorrect writing and reading of large numbers is very much greater than small numbers. To attain these ends I begin all pedigree numbers with the last two digits of the year in which the mother of the corresponding culture was grown, and follow this by the number of the page in my notebook for that year, on which the current notes are entered regarding the offspring of this particular plant. Thus 06230 indicates a plant, the complete history of whose offspring during one generation is

to be found on p. 230 of my 1906 notebook. At the head of that page is given the pedigree-number of the grandmother as well as the mother, thus "0557.230 *Oenothera Lamarckiana* Ser." The maternal year-number, 06, is not necessary here because the entry occurs in the 06 notebook. In tracing out the complete history of the pedigree, I am at once referred by this number to p. 57 of the 05 notebook where I find the data for the parental family with 04156.57 at the top, indicating that on p. 156 of the 04 notebook will be found the occasional notes on the grand-parental generation. At the top of that page appears the number 030.156 indicating that there was no entry in the 03 notebook and that therefore this was the beginning of the culture. In this particular instance there was no 03 notebook since the Station for Experimental Evolution was opened in 1904.

During the course of each season the pedigree-numbers for that particular year become quite familiar. These familiar numbers are carried along on the seed-bag and on the labels in the seed-pans, as a sort of introduction to the new family. Thus in the seed-pan from which the 06230 plants mentioned above were taken, appeared the label 0557.230 just as it did in the notebook. The characteristics of the 0557 family are still fresh in mind and serve as a key to the new family, without always needing to refer back to the records. On removing the plants from the seed-pans to pots, each must have its individual label. The new family has become established in the mind of the operator, and much labor is saved in the writing of labels by dropping the grand-parental number and prefixing the year-number to that part of the former number following the period, thus resulting in the "06230" first introduced above by way of example.

In keeping of notes it will have been already observed that I enter all the data concerning the members of any family on one page of my notebook. These notes are entered in chronological order and dated. Whenever an individual is observed which varies in any notable way a parenthetical number

is added to its label, and this becomes its individual name for the rest of the season. Its label may then appear "06230 (1)" and its peculiarity is described in the note-book on p. 230 under the caption (1). Whenever thereafter a note is made concerning this individual it is referred to as (1) in the note-book. When a second aberrant individual is noted its label becomes "06230 (2)" and so on. These parenthetical numbers are always copied onto the seed-bag when the seed is collected, but are displaced by the regular pedigree-numbers when arrangements are made for the use of particular individuals in the continuation of the cultures.

As only a small proportion of the individuals of one season's pedigrees can be used for their continuation in the next season, it will be seen that the notes on these elected specimens will be scattered among notes on others which it is decided to follow no farther. It is a matter of great convenience therefore to bring together all of the entries regarding any individual to be used as the parent of a new culture and put them into shape for the most ready reference. This I do in the form of a card catalog, using the ordinary library card of good heavy grade. As this is the most accessible reference to the characteristics and history of each unit in the direct line of the pedigree, the cards must be substantial enough to withstand continuous use. At the top of the card appears the double pedigree-number exactly like that at the top of the page in the note-book, together with its equivalent parenthetical designation, thus permanently recording the equivalence between the new number and the one by which this individual was known in the note-book, e. g. "06230.16=(1)": In the upper right hand corner of the card is the characteristic of the year, (07 in this case) indicating that the offspring of this plant will bear the label 0716. This is necessary because in some cultures two or more generations may be raised in one year, or a pedigree may be omitted for one or more years and then resumed. On the next line appears the name of the species. Below this is given

the history of the particular plant "(1)" which has now become "16", stating among other things how it was pollinated. Then follows a statement of the characteristics of this plant, and finally, if it has been cross-pollinated, a description of the pollen-parent. These cards form a complete and permanent record of all the factors entering into the direct pedigreed lines. They are arranged alphabetically by species, (*Oenothera Lamarckiana* in this case), then according to the year number (07 in the example cited) and finally according to the value of the permanent individual pedigree-numbers (16 in the example given).

Besides the records already mentioned I have an index to the cultures, arranged according to the pedigree-numbers, which saves the necessity of referring to the larger note-books when it is only desired to know what species is concerned in a culture bearing any given pedigree-number. The head-gardener has his note-book also in which is noted every act of his which in any way affects the cultures, as seed-sowing, potting, and repotting, transplanting to the garden, all deaths and other casualties, etc. All these notes are entered in his note-book affixed to the pedigree-number found on the labels and are arranged chronologically, each note being made at the close of the event recorded and before a new task is taken up, thus insuring that the entries shall represent observations and not remembrances. The Station for Experimental Evolution has been very fortunate in the choice of its head-gardener, and I take pleasure in thus publicly acknowledging my indebtedness to the honesty, faithfulness and accuracy of Mr. Leo Macy for a large measure of the all but perfect control which it has been possible to attain in the plant-breeding work at the Station.

There is no way in which pedigree-cultures may be carried on for scientific purposes which does not involve the copying of pedigree-numbers, and it is necessary that this work be done with the greatest care. In such work it is well to acquire the habit of looking a second time to see that the

number has been correctly transcribed, as laxity in this regard would be another fruitful source of fatal errors. Even with the utmost precaution an occasional lapse will occur. The proper procedure then is to eliminate with a firm hand. Perfect integrity and no guess-work are fundamental prerequisites of success and reliable results with the pedigree-method.

ACRES OF LIVERWORTS.

BY PROF. HENRY S. CONRAD.

Doubtless every bryologist knows of some spot where he can find, or has found, the horned liverworts (*Anthoceros*). I used to be told of a good bog at Woods Hole, Mass. Another person had seen it beside a certain watering trough out in the country near Philadelphia. It was with some surprise, therefore, that I began a few years ago to find *Anthoceros* in nearly every moist meadow, and beside every spring and brook and wet ditch. By its dark watery green color and slightly wavy surface, *A. laevis* may be certainly recognized before the horn-like sporophytes have appeared. When little wart-like antheridia are present, the identification is still more sure.

In drier places one soon finds another *Anthoceros*. The thallus is of a bright, often almost yellowish, green and the surface is covered with a forest of lobes and papillae. This is *Anthoceros punctatus*.

Some time when hunting for *A. laevis* you find a circular thallus one-quarter to one-half inch across, wrinkled at the edges, and with tiny, yellowish, curved or straight sporophytes projecting horizontally from their sheaths around the margins of the thallus. This is *Notothylas orbicularis*. We find it very often, along with *A. laevis*.

It was only by chance that I became acquainted with *Riccia*. For years a single round and much branched thallus collected on a clayey brook bank was my only specimen. Then *R. crystallina* appeared in two back yards in West

Philadelphia. It has a light green velvety thallus about one-sixteenth inch wide, much branched, and often forming patches an inch across from a single spore.

A year before this I began to find *Fossombronina*. On moist shady road banks with north exposure, or on the south side of a little hole in the ground these plants appeared. They too soon became common.

But nowhere have I seen these forms, and several others, in such quantity and luxuriance as in Bucks Co., Penna., about five miles west of Trenton, N. J. Here in a corn field, on clayey soil, I have twice seen the whole surface of the ground for acres densely covered with *Riccia crystallina*! One usually needs to get his face within a foot of the earth when hunting liverworts. But in the above named locality, "he who runs may read." This was the condition in August and September. That particular field yielded a crop of hay this year, but since harvest I find those same acres equally covered with *Anthoceros laevis*, *A. punctatus*, *Notothylas orbicularis* and a *Fossombronina* (probably *F. dumortieri*)—literally acres of them! In the middle of August *A. punctatus* is nearly dead. *Fossombronina* is laden with yellow antheridia. The plant itself is of a light green color and grows in dense beds often five inches long by one or two inches wide. It crowds out everything else. Among all these forms *Fimbriaria tenella* is rapidly spreading, but showing no signs of fructification (August 24).

Two more fields, one on either side of that just described, are equally overrun with the same plants among the stubble. And another field a mile south is the same. One of these fields produced a crop of oats this year, sown in the second week of April. Here *Anthoceros punctatus* was fully mature on August 1st. Another field, planted with potatoes, was last cultivated about July 1st. On August 24th it had large and apparently mature plants of *Riccia crystallina*. Along the woods-road near by, the path was green with *A. laevis* on the 8th of July. Beside the brook in the meadow on

August 23d I secured a sod of this plant six by four inches. Near this *Pellia epiphylla* forms beds a yard square. Every thallus tip bears at this season a cup of archegonia. A hand lens reveals the swelling embryos. Slightly prominent antheridia are plentiful on the backs of the bright clear green thalli. A quarter of a mile down stream *Fegatella conica* is equally plentiful, and with many antheridial excrescences.

While this particular region must be exceptionally rich in these interesting plants, I have seen *Anthoceros* almost as plentiful—acres of it—in Chester Co., Penna., near Downington, and large quantities in the vicinity of Baltimore, Md. And in the middle of Iowa we collect the three horned liverworts in company with *Marchantia polymorpha*. I am convinced, therefore, that the Anthocerotes should be reckoned among our commonest plants. If so, this is very fortunate, because of their great biological and phylogenetic importance. —Grinnell, Iowa.

LIST OF COLORADO TREES.

BY MRS. CORA BENNETT.

Last year, at the suggestion of Professor Francis Ramaley of the University of Colorado, the writer prepared a tabulation of the distribution of some Colorado trees. In doing this work a list of all the trees known in the state was prepared. This list may be of interest to western students but more particularly to visiting botanists who are wont to think of Colorado as being very poor in tree species. All of the trees except two in the accompanying list are given in Rydberg's *Flora of Colorado*, but they are not separated out so that they can be found. A few species given by Rydberg are omitted here as probably they do not occur in the state.

Pinus aristata Englm. Foxtail Pine.
Pinus scopulorum Oreg. (Engelm.) Lemmon. Rock Pine.
Pinus murrayana Oreg. Com. Lodgepole Pine.
Pinus edulis Engelm. Pinyon Pine.
Pinus flexilis James. Limber Pine.
Picea parryana (Andree) Sarg. Colorado Blue Spruce.
Picea engelmanni (Parry) Engelm. Engelmann Spruce.
Pseudotsuga mucronata (Raf.) Sudw. Douglas Spruce.
Abies lasiocarpa (Hook.) Nutt Balsam Fir.
Abies concolor Lindl. White Fir.

Juniperus communis Linn. Juniper.
Sabina scopulorum (Sarg.) Rydb. Cedar.
Sabina monosperma (Englm.) Rydb. Cedar.
Sabina utahensis (Englm.) Rydb. Cedar.
Populus tremuloides Michx. Aspen.
Populus wislizeni (S. Wats.) Sarg. Cottonwood.
Populus sargentii Dode, (*P. occidentalis* Rydb.) Western Cottonwood.
Populus acuminata Rydb. Lanceleaf Cottonwood.
Populus angustifolia James. Narrowleaf Cottonwood.
Populus balsamifera Linn. Balsam Poplar.
Salix wrightii Anders. Willow.
Salix amygdaloides Anders. Peach Willow.
Salix exigua Nutt. Narrowleaf Willow.
Salix nuttallii Sarg. Black Willow.
Salix bebbiana Sarg. Bebb's Willow.
Betula andrewsii A. Nels.
Betula fontinalis Sarg. Canyon Birch.
Alnus tenuifolia Nutt. Alder.
Quercus utahensis (A.DC.) Rydb. Oak.
Quercus leptophylla Rydb. Oak.
Celtis reticulata Torr. Hackberry.
Cercocarpus parvifolius Nutt. Mountain Mahogany.
Crataegus erythropoda Ashe. (*C. cernis* Nels.) Thornapple.
Crataegus colorado Ashe. Thornapple.
Crataegus coloradensis Nels. Thornapple.
Crataegus wheeleri Nels. Thornapple.
Crataegus saligna Greene. Thornapple.
Sorbus scopulina Greene. Mountain Ash.
Prunus americana Marsh. Wild Plum.
Prunus pennsylvanica Linn. f. Red Cherry.
Prunus melanocarpa (Nels.) Rydb. Choke Cherry.
Robinia neo-mexicana Gray. Pink Locust.
Acer glabrum Torr. Mountain Apple.
Acer negundo Linn. Box Elder.
Acer texanum Pax. Box Elder.
Fraxinus anomala Torr. Ash.

The above list is probably about complete except for the willows. Many species of *Salix* which are ordinarily only bushes may at times be truly tree-like. It is thus very difficult to say that any known shrubby species is never a tree. It is hoped that additions to the tree flora of Colorado may be recorded in the "Plant World."—Boulder, Colorado.

A WATER-STORAGE ORGAN IN CUSCUTA.

A species of *Cuscuta* found in Northern Zacatecas, Mexico, presents what appears to the writer an unusual structure for this genus, so far as he is able to recall the records. This consists in a bulbous enlargement of the hypocotyl, involving also the radicle. The bulb is short spindle shaped, 4 mm. long with a thickness of 2 mm., the lowest 8 mm. consisting of the radicle. It is white, while the upper filiform portion of the stem is yellow. The whole of the bulb is normally below the surface of the ground, the radicle and lower part of the bulb producing root hairs. Being translucent, the vas-

cular tissue may easily be seen within; its cortical tissue consists of enlarged cells, especially in its outer zones. The bulb gradually elongates till it attains a length of 8 or 10 mm., at which time the stem, leafless of course, has grown to a length of 60 mm. or somewhat over. After this size has been attained, the rootlet and bulb gradually give up their contents to the elongating stem. The suggestion lies at hand that the organ described is a special adaptation to the conditions of the desert, which would be interesting, if true. The suggestion has however this merit that it would be worth while to make a comparative study of the germination of a number of species of *Cuscuta*, both from the region where they are most abundant, and where the conditions for germination are not so perilous and from other desert regions. —F. E. Lloyd.

The Bulletin of the Torrey Botanical Club for January is devoted to the life and work of the late Professor L. M. Underwood. It contains a biographical sketch by Dr. C. C. Curtis, an appreciative memorial by Dr. M. A. Howe, and an account of Professor Underwood's relation to the New York Botanical Garden, by Dr. N. L. Britton. In addition a bibliography of Prof. Underwood's published work is contributed by Dr. J. H. Barnhart.

The twenty-fifth anniversary of the work of Professor Sergius Nawaschine, University of Kief, Russia, was celebrated March 3, by his students and friends. Congratulatory letters were received from scientists all over the world. Professor Nawaschine is best known in America for his morphological and cytological studies on the higher plants.

Dr. J. N. Rose, Assistant Curator of the U. S. National Museum, will leave Washington late in March for an extended tour of study of cacti in the southwest. He will spend the month of April at the Desert Laboratory at Tucson.

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A SEARCH FOR RUSTS IN COLORADO.

BY PROF. J. C. ARTHUR.

For a number of years cultures of the *Uredinales* have been carried on by the writer during the spring season, in order somewhat to unravel the mystery of the heteroecious rusts. When nature bursts into leaf as the sun creeps northward, the rusts that have lain dormant during the winter start into life along with the anemone and spring beauty, the gooseberry and thornapple. At this time the dormant rusts of the heteroecious sort may be found on one host, and the young growth on the alternate host. To find a tuft of grass covered with spores of the preceding season's crop and in contact with it some tender shoots with bursting æcia, furnishes the best of circumstantial evidence of their genetic connection. If some of the wintered spores yet remain ungerminated, taking them to the greenhouse or sheltered garden and sowing on the associated plant brought from an uninfected locality, will demonstrate the soundness of the inference. To trace a burglar by his footprints in the snow, it is best to start early before casual passers-by have obscured the evidence; and to trace the heterœcial transfer to the alternate host, it is best to be in the field early before later infections and stray spores have started rusts on many plants and destroyed the significance of juxtaposition.

Short trips have been taken each year for gathering material and making observations for the work, and one species after another has yielded up the secret of its life-cycle. Finally, inspired by the fame of Colorado for its abundant

and varied rust-flora, it was decided that a thousand miles was not too great a distance to go for a few observations at first hand among its cañons, its mesas, and its mountain slopes.

Enthusiasm for the undertaking was augmented by a visit early in spring to Lake Forest, Ill., a distance of one hundred miles, where during an afternoon the two species of *Gymnosporangium* previously reported from the locality by Professor R. A. Harper were found, together with the previously unknown species for the locality, *G. clavipes* and *G. clavarialeforme*, and also a number of grass and sedge rusts, all in condition for culture work. The round trip consumed but sixteen hours, and yielded eight species of rusts, whose culture promised considerable addition to recorded knowledge.

Judging from this experience it was thought that a trip to the mountains of five to seven days would yield most abundant returns. But as the plans of men oft go awry, so for reasons that could not have been foreseen the required time was deplorably underestimated, but the botanical returns were so valuable that the time was not regretted, and it appears worth while to give some account of the trip.

The start was made from Lafayette in central Indiana on April 25, in company with Mr. Frank D. Kern, who shares equally with the writer in all credits due for successful collections and observations. In the daily papers we saw brief notices of belated snows in Colorado, and were somewhat disquieted the next day upon observing white patches from the car window as we approached Nebraska. The areas of snow gradually multiplied until the whole landscape was a winter scene. Before darkness had fallen, however, the snow was left behind, and our spirits rose accordingly. Late that evening we were met at the hotel in Denver by Mr. E. Bethel, a resident of the city, who planned trips for the next two days, and to whom we are indebted for many courtesies during our stay, his intimate field

knowledge of the rust-flora of the state enabling us to reach most interesting localities without loss of time.

Our first observations were made at Eldorado Springs, an hour's ride north of Denver. Here were seen brilliant yellow æcia on *Arabis*, uredinia on *Cerastium*, and telia on *Poa* and a number of other grasses, but the only observation in line with the object of our explorations was made on *Agropyron* rust. The abundance of the rust on the wintered-over leaves at the opening of the principal cañon seemed a good omen for our final success, and when we came across a few pýcnia on half grown leaves of *Clematis ligusticifolia*, which lay in contact with the rusted grass, and could find no other rusts in the immediate vicinity, we were greatly elated, for it would seem that we had found the true *Puccinia Agropyri* E. & E., which European botanists have identified with *Aecidium Clematidis* DC., but which has not been proven with American material.*

The next morning at eight o'clock, in company with Mr. Bethel as guide, we set out for a cross-country, all-day tramp to Boulder, four miles away as the crow flies, but seemingly quadruple that distance as we went over the foothills, first climbing abruptly, then dropping into a deep cañon, or zigzagging back and forth along the mountain side to shun precipitous slopes. The clouds hung low all day, shutting out of view the mountains and distant landscape, and toward evening the fogs rolled up the valleys from the low land. Being restrained from the enjoyment of the scenery, enabled us to give undivided attention to the rusted vegetation at our feet. As we studied one situation after another enthusiasm ran high, and could not be checked even by the cold wind and occasional flurries of snow.

We found a number of grass and sedge rusts during this tramp, some in great abundance, but the only one requir-

* Owing to delay in sending this article to the printer, it is possible to append the results of the after study of the material. For record of successful cultures with *Agropyron* rust see Jour. Myc. 14:12. 1908.

ing mention it that on *Poa*. Unlike all other grass and sedge rusts coming under our observation during the day, this one exhibited not only the wintered teliospores, but also some freshly developed uredinia: either the infection had come from occasional urediniospores which had withstood the vicissitudes of the winter, or it had arisen from aeciospores derived from the spring crop on the alternate host. At first we were inclined to the former explanation, especially as we never could find a uredinially rusted *Poa* growing in contact with a plant bearing mature aecia of *Aecidium monoicum* Peck, with their brilliant yellow spores. This aecial form belongs to a rather small class in which the mycelium is either perennial in the tissues of the host, or is derived from the previous season's infection, thus enabling it in either case to bear aecia as soon as the host begins its spring growth. From the fact that the aecia were so early that there had clearly been time to infect the *Poa* and develop the uredinia, together with the fact that the infested *Arabis* and the infested *Poa* appeared to be near one another, we reluctantly concluded that they might be genetically connected, although we could not secure the additional evidence of immediate juxtaposition. Plants of *Arabis* from an uninfested locality, and resting spores of the *Poa* rust were secured, and cultures will be attempted later to decide the question.*

Another rust calling for elucidation was found on *Allium*, evidently the *Puccinia mutabilis* D. & H. The dark green leaves of the *Allium*, only a few millimeters wide and ten to fifteen centimeters long, bore golden yellow uredinia, usually near the tips, that were very readily seen. So close to the uredinia on each leaf that one could believe them to arise from the same mycelium, and usually nearer the tip, were telia, sometimes freshly opened, but more often old and dried. The problem was how this autoecious species,

* Cultures did not confirm the inference of genetic connection, although they did not entirely disprove it, see Jour. Myc. 14:12. 1908.

understood to possess all spore forms in its life-cycle, could start out in early spring with telia followed by uredinia, without a trace of pycnia or aecia. It appeared as if the normal order of pycnia, aecia, uredinia and telia had been reversed; and it took some time to unravel the mystery. By a number of small increments of observation the ultimate conclusion was reached that the dried telia were the product of the previous season's growth, and in confirmation of this, many wholly dried and shrivelled leaves were found covered with telia. It was seen that the green leaves that were found had remained green through the winter, and kept the mycelium alive that gave rise to the fresh uredinia, to be followed in the few instances where sufficient time had elapsed by fresh telia. The adjoining old telia were always on the dried tips, indicating that, like the old telia on wholly dead leaves, they were the product of the previous season. Finally a single collection was fortunately made of pycnia and very young aecia, that must have freshly arisen from telial infection derived from wintered spores. The reason why more aecia were not found was clearly due to the lack of sufficient time for the wintered teliospores to germinate, infect a new leaf, and secure development since the beginning of spring; and the reason why abundant uredinia were found was because their formation from existing live mycelium in the persistent leaves required far fewer days of warm atmosphere. This brings to light an interesting instance of the wintering of mycelium, a method not uncommon in grass and sedge rusts, but rather rare in other herbaceous plants. *

It was also in this cross-country trip that we were introduced to the cedar rusts of Colorado, which constitute a largely unworked portion of its fungous flora. In a narrow gorge a few trees of *Sabina scopulorum*, the common red cedar of the region, were pointed out by Mr. Bethel, on which he had previously collected a bark rust. We found

* Cultures confirmed the inference drawn, see Jour. Myc. 14:23, 1908.

that on the larger branches and to some extent on the smaller ones, were knots and rows of excrescences with protuding brown masses, now conspicuous by reason of the moist air swelling the gelatinous matrix of the spores. Except in color they reminded one of the well-known distortions produced by the black knot of the plum. A few feet away, and forming a part of the same clump of shrubbery, were thorns, probably *Crataegus cerronis*, on which Mr. Bethel pointed out mummied fruit of the previous year, still showing remains of a more than usually firm *Roestelia*. Other hosts, which might harbor the aecia of this cedar rust, appeared to be absent in the vicinity, and Mr. Bethel assured us that in a number of visits to the place, when such aecia are at their best, he had seen none other. Both these forms, aecial and telial, have gone under names clearly inappropriate, and are doubtless yet undescribed, * in spite of both being more than usually conspicuous, due in large part to the conservative method of using eastern or European names for western plants so long as there is no authoritative denial. Portions of branches bearing teliospores were taken, with which to start cultures upon reaching home, and thus testing the assumed connection between the forms of rust on thorn and cedar. **

Some less striking examples of the same rust were found before reaching Boulder, which was now not far off. At five o'clock a call upon Prof. T. D. A. Cockerell in Boulder, with some memorable discussion upon the probable method of evolution of specific forms among the rusts, taken over a cup of tea, and the active part of a very profitable day in field observation and collecting came to an end. An evening train took us back to Denver.

The next day being Sunday we rested and tried to make plans, but a heavy fall of snow in the latter part of the day completely upset our calculations. Monday a beauti-

* Since described and named by Mr. Kern, see Bull. Torrey Bot. Club, 14:159, 1907.

** The cultures were successful, see Jour. Myc. 14:23, 1908.

ful white mantel covered the landscape and especially our world of rusts, and gave no evidence of disappearing, so rather than be idle or abandon our quest, we took train for Glenwood Spjrrings in the western part of the state, where we enjoyed a half day's collecting under a clear sky and amidst rich verdure before a snow storm of midwinter character again brought our work to a stop.

In this locality we hoped to find live material of a *Gymnosporangium* on *Sabina* of which only one or two old galls, occurring on smaller branches, quite regularly globose and an inch or more in diameter, had so far been seen, and to which no reference had been found in literature. * Following directions of Mr. Bethel, who had brought the form to our attention, we went down the valley to the south, and secured a small amount of material. But we were especially delighted in finding an abundance of *Gymnosporangium speciosum*, which was named many years ago by Mr. Peck, but of which only a few meager specimens have been preserved in herbaria. The gelatinous masses formed conspicuous yellow lines along the smaller and larger branches of *Sabina Utahensis*, the prevailing cedar. A very careful search in this vicinity revealed no traces of *Roestelia* on *Crataegus* or *Amelanchier*.

It was here that we saw a few green twigs of the cedar slightly smeared with the brown spores of some *Gymnosporangium*, giving an unfamiliar look, but passed over as an accidental occurrence. Later in the day a tree near the Hotel Colorado was found to have nearly every branch similarly affected. Such dissection as a pen-knife and hand lens permitted showed quite conclusively that the brown lines of glutinous material had ozzed out from beneath the scale leaves, and that we had discovered a very small species of *Gymnosporangium*, new to science. ** A search was at once begun for possible aecial suggestions, and quickly rewarded

* Since described under the name *G. durum* Kern, see Bull. Torrey Club, 34:460. 1908.

** Since given the name *G. inconspicuum* Kern. see Torrey Bull. Torrey Club, 34:461. 1907.

by seeing many mummied fruits on the nearest bush of *Amelanchier*, not over ten yards away, that bore the remains of some *Roestelia* possessing a firm peridium not easily affected by the weather, and which we subsequently learned had in consequence been referred to *Roestelia Harknessiana*.*

Earlier in the day we had seen similarly affected fruit hanging to clumps of *Amelanchier*, with many small trees of cedar near, and even with branches intermixed, on which we had been able to detect no *Gymnosporangium*. . . Darkness held in check our desire to revisit these spots, and even in the morning it was necessary to await a lull in the snow storm that had overtaken us. On arriving at the place where the day before no *Gymnosporangium* was visible to our rather careful scrutiny, we found every cedar that was not too far from an affected *Amelanchier* to be sticky with the brownish yellow masses of the rust. The melting snow had after all served us a good turn by swelling up the usually inconspicuous telia into quivering jelly masses of the size of peas. As it was apparent that the greatest amount of the brown jelly occurred on trees nearest to *Amelanchier* with mummied fruit, the conclusion was simply that the two fungi bore a reciprocal relation. Telial material was carried away with much confidence that sowings on *Amelanchier* fruit would produce fresh *Roestelia* corresponding to those seen in weathered condition.**

Both the weather and the limits of time now made it advisable to bring our collecting trip to a close. In twelve days from the time of starting we were again in Lafayette with much valuable material for both cultural and systematic study, and a knowledge of field conditions that no other means could adequately supply.

There are few localities in any part of the country that do not possess some species of rusts worthy of careful attention. Each locality will require a number of seasons to reveal

* The name since given to this is *Roestelia Harknessiana* (Nesb.) Kew, see Bull. Torrey Club, 34:463. 1907.

** The cultures were successful, see Jour. Myc., 14:24. 1908.

the wealth of its rust flora. To show one way in which the study may be pursued, has been the purpose of this narrative. It is best to begin at home where the same locality may be visited repeatedly, and afterward to roam afield in search of new forms and new conditions. At times even such a seemingly unfavorable occurrence as a snow storm may be turned to account by the enthusiastic hunter for plant-rusts.

SUGGESTIONS CONCERNING CERTAIN BUD VARIATIONS.

BY EDWARD M. EAST.

It is to be regretted, that in spite of the marked interest in bud-variation, it has been given but little analytical study. Perhaps this is because the comparative rarity of their occurrence makes laboratory material difficult to obtain. Even in De Vries' monumental work, where much might have been expected, the subject is given only a scant ten pages; and no explanation to fit our modern biology is submitted. One glimpse of light is given by Darwin, however, when he suggests that a few of these phenomena might be explained by "segregation of the paternal characters in seminal hybrids by bud-variation." The thought is almost a precursor to the conception of unit characters.

My own idea of bud-variation is that it is much the same as germinal mutation; although there is little direct proof of this statement. But we must admit that if mutation is due to some shuffling and distribution beyond the normal, of the cell units that are the basis of somatic characters; then the same stresses and strains that produce such changes upon the germ cell, should produce analogous changes upon the somatic cells that lay down certain plant organs. We should probably find the vegetative changes the rarer of the two, because conditions during cell division are more nearly uniform with branches from the same rootstock than with separate individuals. The idea of the similitude of both

forms of mutation is corroborated by the fact that species that produce many bud variations, also produce many germinal mutations; and these germinal and vegetative variations are often similar, and many times are identical. Some of these vegetative changes undoubtedly affect the germ cells, for they are transmitted by sexual reproduction; others appear to be changes only in somatic structures. In certain bud mutations there seems to be an inertia of cell division that keeps the mutation true when propagated vegetatively for long periods of time, even when sexual reproduction always induces a return to the normal form. Other changes that have appeared many times in horticultural history, have never been fixed by even the strictest selection.

As long as there is no definite reason to believe that bud mutations are specifically different from germinal mutations, De Vries' grouping into progressive, degressive and retrogressive mutations can here also be used. If then bud variations belong to these three groups, the questions of greatest practical importance are: What is the frequency with which these groups occur in nature? What is the cause of each? Can they be produced at will?

If progressive mutations are relatively common, then we may expect to obtain varieties with absolutely new characters by this means. If, however, progressive mutations are very rare, then bud mutations will give but few novelties of real agricultural worth. Degressive and retrogressive mutations are confined to rather narrow lines. They produce and reproduce certain definite variations in characters having little economic value. Moreover these variations show greatest similarity to existing biotypes of the species. In floriculture, where slight differences in color and other minor characters are important, such changes may be of value; but it is unlikely that there will be changes in factors which go to make up quality in agricultural products.

I believe we should omit from discussion those variations that will probably admit of different explanation. For

example, the addition of petals, or the change of other flower organs to petals are merely changes affecting the internal correlation of growth, in the sense used by plant physiologists. In these cases there is simply an abnormal cell division at a critical point, so that there are two organs laid down instead of one. There is neither the addition nor the loss of an actual character.

The production of variegated plants is also a common occurrence. These phenomena apparently belong to the same general class as the production of "mosaic" or "calicoed" tobacco plants; and the latter condition we know can be communicated by touch. It is probably that some, at least, of the cases of variegation will prove to be pathological.

After discarding representatives of these two classes, a random sample of one hundred cases of bud variation showed about eighty cases that beyond a reasonable doubt yield to the following hypothesis:

In the large majority of cases of bud variation there has simply been the *loss* of a *dominant* character, and hence the appearance of a *related recessive* character.

In making this statement, use is made of Bateson's theory that there is either "presence" or "absence" of certain factors, in the Mendelian phenomena. As an example, consider the "starchy" character of dent maize, contrasted with the appearance of "sweet" maize due to its inability to mature its starch. When there is *presence* of the dent character in the germ cell, we have the characteristic appearance of such varieties. In the *absence* of the dent character, the endosperm may be said to ripen, but not to mature, and there is left the appearance peculiar to sweet maize. We can imagine the leaving behind of just such a character in bud variation, and the appearance of the recessive allelomorph. In some cases there is absolute disappearance of the dominant character, and it never again appears; in other cases there appears to be a latency of the dominant character, and

hence, the possibility of its reappearance when conditions are right.

I give below some evidence relating to this question. It is confined to three of the most common types of bud variation. In this data, there is but little direct evidence as to probable Mendelian behavior in specific cases. There are, however, analogous instances, where the behavior of similar characters after crossing has been recorded.

Variations in color form over seventy *per cent* of all bud variations. Color characters have also been the favorites for Mendelian work. They have often been shown to be made up of several factors; but, so far as the writer is aware, presence is always dominant to absence when sap dyes only are considered. The loss of certain color factors could thus account for successive changes of color until entire absence of color is reached. We can, of course, imagine the presence of a factor that excludes the development of a color potentially present, and by the loss of this factor the color is allowed to form. But this seems unlikely to be often the case. We must, however, note that color phenomena are complex. A dark color may obscure a lighter one belonging to a different allelomorphic pair, when present in the same tissue; and loss of the lighter color would be unnoticed. There may also be different colors present in separate tissues, though they are one in appearance. Such are the yellowish plastids that Bateson (*) has found to be recessive to colorless plastids in sweet peas and stocks.

In the tomato, I have discovered four authentic cases in which a red tomato plant has produced a branch that bore yellow fruit; but I have heard of no instance in which a pure yellow has sported to a red. In this plant Hurst (**) has shown that red is completely dominant to yellow.

In the potato, bud variation has been almost confined to color variations. Mr. A. W. Sutton (***) makes this

* Bateson, W. et al. Report to Evol. Com. 3:9. 1906.

** Hurst, C. C. Mendelian characters in plants and animals. Third Inter. Con. on Genetic's 114, 1907.

*** In personal communication.

statement: "I have no hesitation in affirming that there is no potato in commerce today in England, and I might say in Europe, which owes its origin as a distinct potato to bud variation in any form whatever." After a wide inquiry in the United States, I believe that the statement is also true for this country. Mr. Sutton cites "Forty-fold," "Beauty of Hebron" and "Paulsen's Blue Giant" as having varied from colored skins to white. Mr. P. de Vilmorin (*) has kindly given me two instances. They are both the loss of a colored skin. In this country I have seen three color variations, and have collected five others—apparently authentic—that are losses of color characters. But two exceptions to the rule have appeared. Mr. Sutton reports that "Rector of Woodstock," which was originally white, has produced a purple variegated skin. In this case, however, it is unknown whether the parent tuber possessed the power of forming the purple dye, as is indicated in some of our white varieties by their purple sprouts.

There has also appeared a similar variation in the White Pearl, reported to me by Prof. E. R. Bennett. This potato, white in color, with pink sprouts, appear to have produced a purple spotted variety. Old potato growers, however, say that the parent of the White Pearl had a purple skin.

I have no conclusive evidence as to which colors are dominant in the potato, but from the progeny of about 100 crosses that I have observed, I feel certain that the colorless skin is recessive to colors. Only in one questionable case there appears to have been a pink produced by crossing two white skinned varieties. It is possible that in this case a necessary color *factor* was introduced by each variety.

The chrysanthemum is also a plant which produces probably as many bud variations as any one of our cultivated species. On the authority of Mr. Ghys, (**) who has given it a great deal of study, the general tendency is to sport from

* In personal communication.

** Le Chrysantheme, au point de vue du Dimorphisme: Bull. de la Soc. d' Hort. de Loir-et-Cher. Troisième trimestre No. 35, 1899.

purple to red, from red to white, and then to yellow. A pure yellow, the original color of the plant, never produces a color variation. To explain this, we have only to imagine the germ cells of the purple chrysanthemum to contain the factors for determining blue, red, white and yellow colors, and as one or more of these colors are dropped, a different color appears. It is probable that the yellow color is a plastid color, (or at least belongs to a different pair) and hence is recessive to white; while the other colors are sap colors, and are dominant to white, although I have no evidence on this point.

It is safe to say that in horticultural plants whose flowers tend to vary in color, such as carnations, azaleas, geraniums, roses, etc., the tendency is toward the loss of a color factor. There are many cases in which a color is deepened in a variety which already possessed the ability to form the dye, but this is probably a different thing from definite bud variation.

Many instances illustrating the same feature might be given in the fruits: purple plums produce yellow plums, blackberries produce white variations, red currants give white varieties, and dark grapes throw white sports. In nearly all cases there is a definite loss of a color character. Sometimes this loss is permanent; while in other cases the color is not able to develop, but is present in latent state, and may after a longer or shorter lapse of time, again appear. But in these cases the change is not a change in any direction, but a loss or gain of a particularly loosely connected unit character.

A second common type of bud-variation, is the production of cut leafed varieties in different species. In these productions, the character which produces the development of entire leaves is often retained in a latent state, and there is frequently a jump back to the original form. The changes taking place certainly affect unit characters, but there are few data concerning their behavior on crossing. De Vries, how-

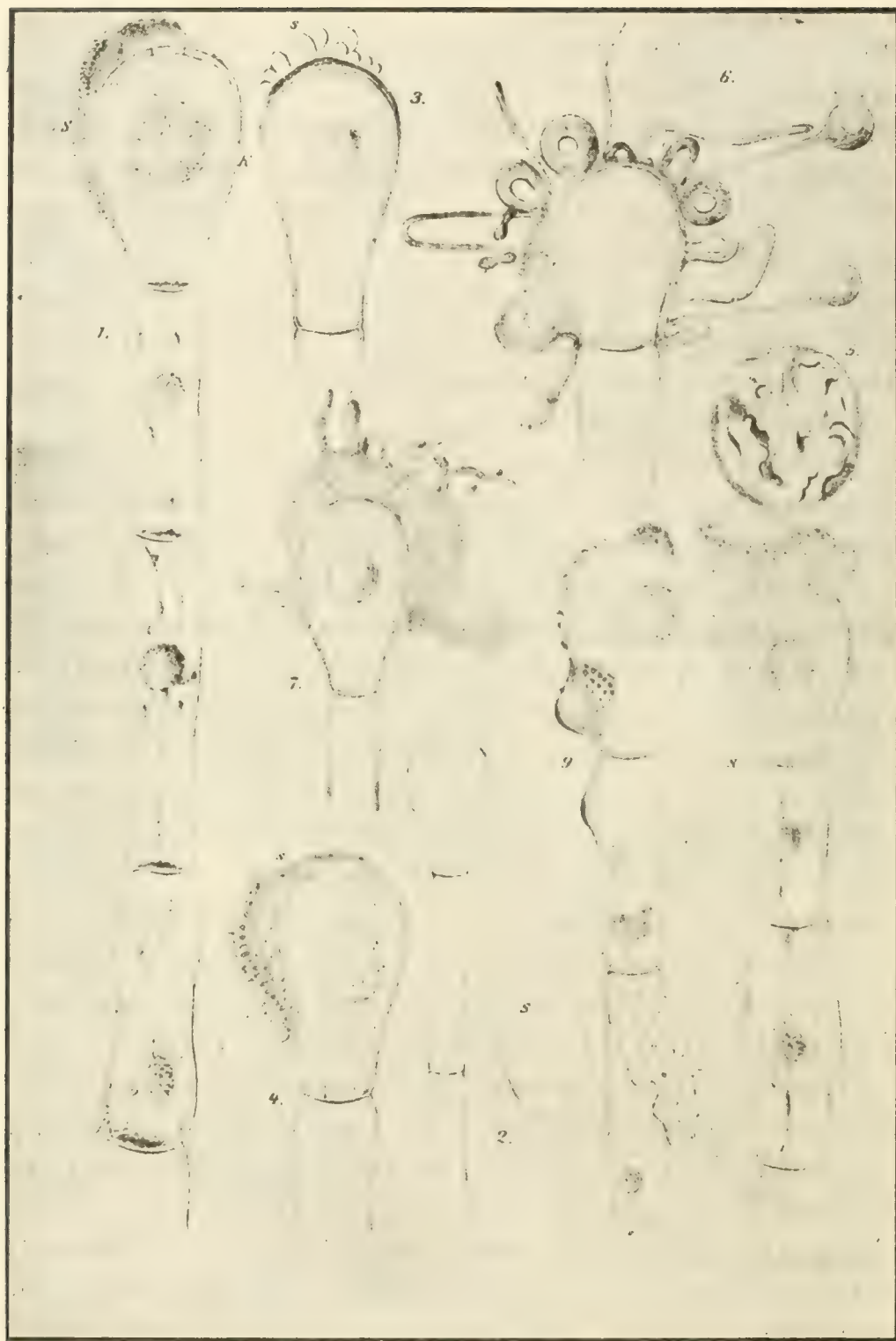
ever, reports that entire petals are dominant to laciniated petals in *Chelidonium majus*.. This evidence is not conclusive, but it seems reasonable that the change is the loss of something that enables the plant to produce entire leaves.

A third group of bud variations, that occurs quite often, is the loss of a prickly, hairy or felted condition. Such characters have been shown to be Mendelian in several cases, in all of which the rough condition is dominant to its absence. The evidence comes from such different plants as *Lychnis*, *Matthiola*, *Datura* and wheat.

The classical example of this type is the loss of the hairy condition in the peach, which produces the nectarine. The moss rose is a second case, although at first thought it might be regarded as an exception to the theory. This rose has been considered to have been derived from the Provence rose by bud variation, but this is not definite. The moss rose was imported into England from Italy, and its definite origin is unknown. It may have originated as a germinal mutation. It seems to be much more definitely recorded that smooth variations have appeared from the moss rose rather than mossy variations out of the Provence rose. At least, the change by loss of a character, is much more common.

These data are merely presented as giving a reasonable explanation of at least 75% of our recorded bud variations. It may be that an increasing knowledge of Mendelism will even extend the proportion of cases to which it is applicable. But even should this not be the case, it seems a rational conclusion that comparatively few bud varieties will come into cultivation through real origin of useful characters. The single idea explaining what is thought to be the common method of bud variation is thought to be worthy of consideration.

Conn. Agr. Exp. Station, New Haven.



Plate—1-6 *Cypripedium pubescens*. 1, glandular hair: k; secreting cell, s, mass of secretion. 2, glandular hair with the structureless and colorless secretion adherent. 3 & 4, glandular hair after the addition of water, the secretion showing a bladder form (or) short filaments (4). 5, a mass of secretion in hot water. 6, appearance of the secretion after treatment with a .2 per cent alkaline solution. 7, a glandular cell from *C. acaule* after treatment with strong ammonia. 8, a glandular hair of *C. Calceolus* in water. 9, a glandular hair of *C. spectabile* in water.

THE POISONOUS ACTION OF LOCO-WEED AND LADIES' SLIPPER.

The ranges of *Astragalus mollisimus* and *Aragalus lamberti* general known as "loco-weed," include several of the more important stock-raising districts of the west. In some regions both species were known to be extremely harmful to grazing animals, while in other places no damage resulted from its consumption by cattle and horses. In all of the earlier investigations of the chemical properties of these plants water extracts failed to show any toxic principles, and hence the reports of the poisonous action of loco by ranchers were more or less discredited. Recently, however, Mr. A. C. Crawford of the Bureau of Plant Industry has found that a toxic principle is present, that it can not be extracted by water, but is readily obtained by the use of solutions of the animal digestive ferments.

Furthermore it was found that this toxic principle could only be obtained from plants grown on soils containing barium, and hence it is reasoned that the poisonous action is in reality due to barium compounds, the effects of which are closely simulated.

The author of this note found that the leaves and stems of three species of *Crypripedium* (*C. Spectabile* Salisb., *C. pubescens* R. Br., and *C. parviflorum* Salisb.) were strongly irritant to the skin of a large proportion of the persons by whom the test was made, confirming various reports that had been made of the matter earlier. An analysis of this action resulted in the localization of the poisonous action in a secretion produced by the large glandular hairs. (Minn. Bot. Stud. 1:32. 1894 and 2:450. 1895.) The publication of these results was followed by many reports of similar experiences, the most recent of which is that of O. E. Jennings with the large yellow ladies' slipper in Pennsylvania, and also the pink ladies' slipper, as described in the PLANT WORLD for August, 1907.

Dr. A. Nestler has recently made an examination of the secretions of these and three other species of *Cypripedium* at the Institute for Plant Physiology at Prague. This material was found to be a colorless, brownish or reddish substance, in which the poisonous compound was probably united with a fatty acid. Some difference was seen in the chemical reactions of the secretions of the various species examined, only one of which exerted a dermatitic action on the investigator, the tests not being extended to any other person, hence nothing was added to present information as to the comparative action of the several species. It is well known that many are wholly immune from the effects of all species of poison ivy and other skin irritants. Dr. Nestler concludes that the poisonous substance of *Cypripedium* is unlike that of *Primula* which he has recently examined and also of poison ivy which was described some time since. The figures of the accompanying plate taken from Dr. Nestler's article illustrate the form of the glandular hairs and the occurrence of the secretion very clearly.—D. T. MACDOURAL.

THE BOTANICAL GARDEN OF FLORENCE.

From the Piazza San Marco, in Florence, with its church and monastery (in the latter of which the visitor sees the cell of Savonarola), if one proceeds southeastward along the Via Lamarmora, he passes on the right the entrance to the Institute of Higher Studies, and comes shortly to a small gate which gives access to the Botanical Garden. The buildings occupied by the Institute, like most of the buildings of Florence, are of plastered stone, dull buff in color. The windows on the ground floor are protected by the common iron grills, and the widely projecting eaves and dull-red tile roofs, with their odd shaped chimney pots, give them a characteristic Italian appearance. Beyond these buildings a high wall, uniform with the buildings themselves, and with red tile coping, continues to the next street, the Via Micheli, named for the famous botanist. Before reaching the gate

now in use, one passes several closed gates, one with an inscription, "Cosmo Med. Dux Florentiæ II." Several iron lamp-brackets overhang the sidewalk, attached high up on the wall, which itself continues beyond the garden gate, around the corner and along the Via Micheli southeastward to the Via Capponi, and then again back southwestward to the church of Santa Annunziata, thus completely enclosing the garden, for the church and Institute buildings close the remaining side of the rectangle. In late February, when I visited the place, a fine show was made by the tops of a group of well-laden orange trees which overhung the wall near the garden gate.

Entering the garden, one finds on his left a series of old plant houses, with their walls and roofs only partly of glass. To the right lie rectangular beds of the herbaceous garden, each representing a family or order of plants and well provided with labels. Scattered about are a goodly number of trees, some of them very large. Among the latter were noticed: several fine magnolias, some very large ashes, a maple or two in bloom at the time, a *Planera richardi* Mchx., four feet in diameter breast-high, with heavily buttressed base; several good-sized yews; a *Pinus excelsa*, of the Himalayas, eighteen inches in diameter; *Pinus fortunei* eight inches with a fine display of the curious broad leaves of this form; *Abies Nordmanniana*, fourteen inches at base; and *Ulmus latifolia* five feet in diameter. A *Quercus suber*, as large as the last named elm, bore a label showing it to have been planted in 1805. Several beeches, about two feet in diameter, had been planted in 1829. A *Quercus Ilex*, about two feet in diameter had been planted in 1805, and a *Cupressus pyramidalis*, of the same size, had been planted only five years later. Some fine camelia hedges bore flower buds at an advanced stage but were not in bloom, although camelias in the open had been loaded with flowers a month earlier at Punta Delgada in the Azores Islands. . A number of large palms were thriving out of doors, as well as several

Pandanus forms. Among the latter are worthy of note a *P. humilis* with a top spreading twenty feet or more, and a *P. odoratissimus* with an even larger top, and with numerous banyan-like roots, two inches in diameter, coming from the lower branches and from the base of the trunk. A *Yucca Australis*, eighteen, inches at base and twelve feet high suggested the southwestern American deserts.

Inside the glass houses were a large collection of exotics in good growing condition. Especially interesting were a number of cactoid forms of *Euphorbia*, some of them ten feet or more in height. Many trees in the houses showed that they had been growing there for many years. Several species of *Citrus* were represented by potted specimens several inches in diameter. Other large trees were rooted in the ground, among these being several *Ficus* trees, a *Dammara robusta*, six inches in diameter and a *Podocarpus macrophyllus*, ten inches through the base. Most interesting perhaps, was a monstrous branched specimen of *Cycas revoluta*, the stem of which had as much the appearance of certain monstrous specimens of the giant cactus which I have seen in southern Arizona. The *Cycas* in question possessed, besides its terminal bud, which was the largest and apparently the most healthy, no less than eight lateral buds or growing points. The trunk rose normally about one foot from the soil and then spread out suddenly in a fan-shaped mass of short and crowded branches. All of these branches had apparently borne leaves at some time, but only one of them had foilage when seen by me. All lay in the same general plane, there being three on one side of the main axis and five on the other.—BURTON E. LIVINSTON.

Munich, Germany, March 18, 1908.

"A. G. T." in *Nature* gives an interesting review of a late work by Dr. Carl Holtermann entitled *Der Einfluss des Klimas auf den Bau der Pflanzengewebe*, which is a report on

the author's anatomical-physiological investigations of tropical plants. The experiments were carried out mainly in Ceylon and include a long series on the transpiration of different tropical plants. "The author's general conclusion from his experiments is that while the highest transpiration figures per hour in the tropics are considerably higher than any northern European ones, yet active transpiration begins later and stops earlier in the day in the case of a damp tropical climate, so the wet season transpiration may cease for weeks at a time." Among the other conclusions of Dr. Holtermann may be mentioned his theory of the function of the water-tissue which he considers an arrangement to supply water to the transpiring tissues during the short periods of high water loss. This conclusion is substantiated in various ways. The strand-plant formations are described by the author, as also the damp lowland woods, the dry plains of the north and the east, the upland vegetation, and the epiphytes and the parasites of Ceylon. The final section of the work is devoted to a discussion of direct adaptation, which reactions are classed under irritability, and draws the conclusion, called unwarranted by the reviewer, that such acquired characters in the process of time can be fixed and inherited.

Professor W. L. Tower, of the University of Chicago, whose extensive experiments by which modifications of beetles were secured by variation in climatic factors have attracted so much attention, is now organizing a new series of transplanted cultures. One of the largest of these is being established at the Desert Laboratory at Tucson, where it will be carried on in connection with the acclimatization plantations of that Institution.

Dr. Geo. H. Shull, of the Station of Experimental Evolution, Cold Spring Harbor, L. I., N. Y., has recently gone to Santa Rosa, California, where he will continue his analysis of Mr. Burbank's horticultural results during April and May.

Professor Wettstein of Vienna, after making a study of the hybrids of *Sempervivum*, comes to the conclusion that the results of crossing in this genus include an enormous increase of fertility of the pollen.

At Munich, on Saturday evening, March 7, a banquet was held in honor of the twenty-fifth anniversary of Dr. Goebel's appointment as Professor. A large number of European botanists were present and the occasion was a very inspiring one. After the banquet, the botanists attended a students' Kommers of the pharmacy students, where more speeches and songs enlivened the remainder of the evening.

The University of Washington will open its marine station at Friday Harbor, Washington, for the 5th annual session, on June 22, 1908. The length of the session will be 6 weeks. The staff will consist of Dr. Charles W. Prentiss of the department of Zoology of the University of Washington, Dr. Robert B. Wylie of the Department of Botany of the University of Iowa, and Professor Charles O. Chambers of Pacific University, Forest Grove, Oregon. The chief features of the station are its location in the heart of an evergreen forest in the winter rain belt, the abundance of marine plants and animals, its constant use of the dredge, and its small fees (\$13.00).

Dr. Charles A. Davis of the University of Michigan, connected with the Michigan Geological and Natural History Survey, and acting as peat expert of the U. S. Geological Survey at the recent Jamestown Exposition, has had his appointment to the latter made permanent, in order to make a thorough study of the nature and origin of peat. He finds that many salt marshes along the Atlantic coast are underlain by peat, formed from fresh water plants, and that they may throw much light on the history of subsidence of this coast. The Michigan Survey has recently published a report embodying a series of papers by Dr. Davis, treating of the origin, nature, distribution, and commercial aspects of the large peat

deposits of that state. One of the most interesting facts brought out is that contrary to the view long held by geologists, *Sphagnum* moss has really little to do with the formation of peat deposits, and that the plant mainly concerned in building the characteristic sedge mat of northern lakes, which ultimately becomes the basis of a peat layer is *Carex fliforme*.

Graft-hybrids, in which the qualities of two species have been brought together and interlocked in one individual produced by the blending of the characters of a cion and stock have not been produced, although many assertions to the contrary, not supported by adequate proof have been made. Dr. Winkler has, however, succeeded in bringing together the characters of night-shade (*Solanum nigrum*) and the tomato (*Solanum lycopersicum*) in such manner that the organs on one side of the shoot formed bore the characters of the nightshade and the other those of the tomato. (Ber. d. deut. bot. Ges. 25:568. 1907.) This was accomplished by decapitating a young tomato-plant and repeatedly removing the branches and young shoots formed on or near the callus, until at last it was possible to seat a graft in the callus, the meristematic cells of which evidently joined with cambium of the callus to form a shoot. The first leaf formed on the new shoot was of the nightshade type, the second and third of the tomato. In the further development of the shoot the 4th, 5th, 7th and 19th leaves were of the nightshade type, while the 6th, 8th and 9th resembled quite exactly those of the parent tomato. The 11th leaf, however, arose from a mass of cells comprising some from both parents with the result that the left half resembled the nightshade while the right half consisted of three pinnatifid segments such as those borne by the tomato. The contrast between the two is very striking from the fact that the leaves of the nightshade are entire while those of the tomato are pinnately divided.

The phenomena most nearly related to these results are to be found in seminal hybrids in which the parental characters are frequently segregated in bud-sports.

A text-book by Dr. K. Goebel on the subject of experimental morphology of plants (Einleitung in die experimentelle Morphologie der Pflanzen) has recently appeared from the press of Teuber, in Leipsic. A further account of the work will be given in a later number of the PLANT WORLD.

Dr. F. M. Andrews, of the University of Indiana, is occupying the Smithsonian table at the Naples station for marine biology. He will return to America in the early summer. In the new building of this station several rooms have been set aside for research in botanical lines.

Dr. Wm. A. Setshell, Head Professor of Botany at the University of California, will spend his summer vacation examining the algae in certain European herbaria, especial at Copenhagen and Paris. He leaves Berkeley on April 30.

Mr. T. S. Brandegee, of the University of California, will depart early in May for Mexico, where he will join Dr. C. A. Purpus and spend several months botanizing in Puebla and neighboring states.

Dr. J. N. Rose, of the U. S. National Museum, is engaged in making a field study of the Cactaceæ of the Southwest. His headquarters are at the Desert Laboratory.

Dr. Douglas H. Campbell, Professor of Botany at Stanford University, spent a portion of his spring vacation at the Desert Laboratory and made a brief examination of the plants in the vicinity of Tucson.

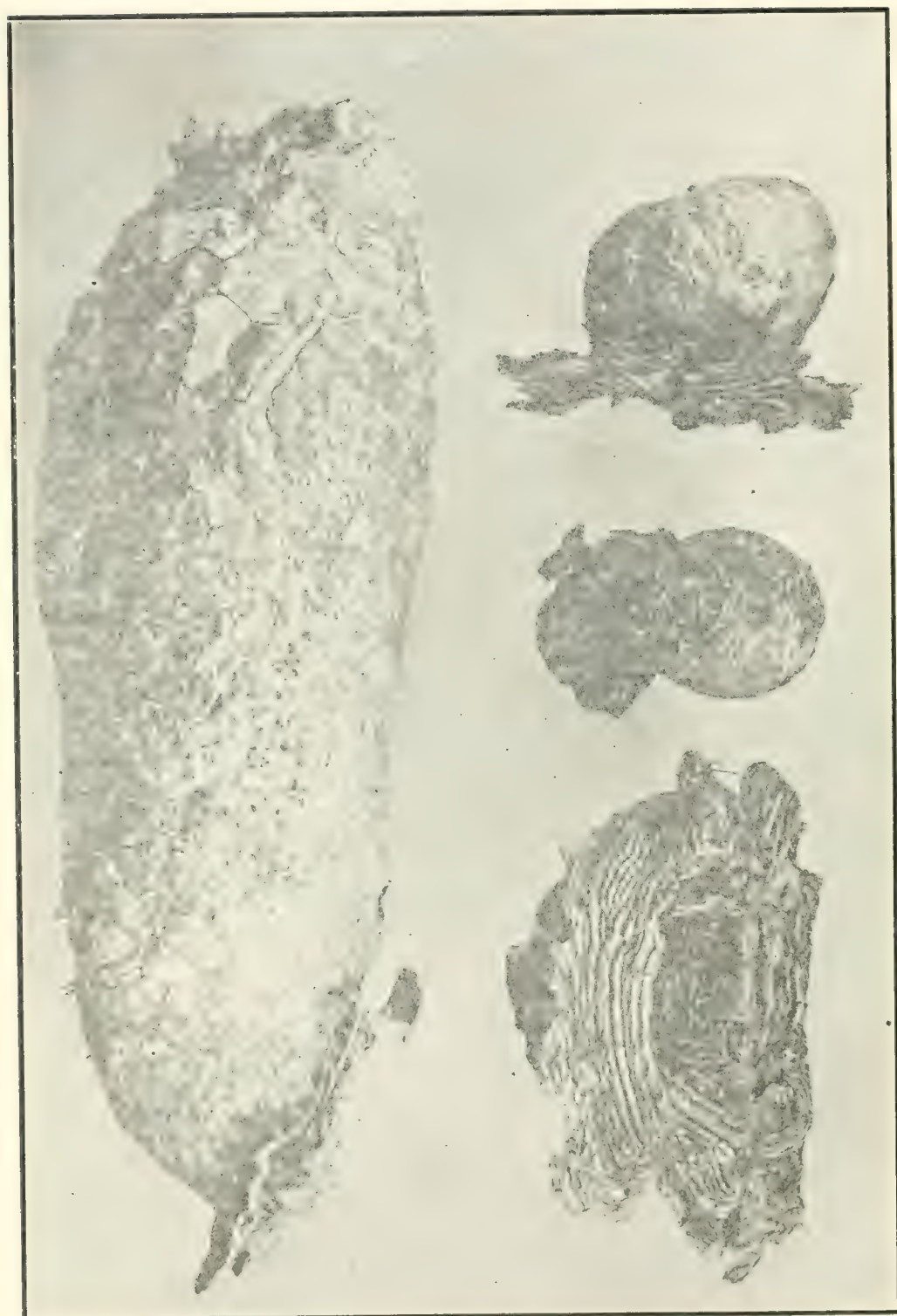


PLATE 1. Callus pouches of the salivary gland formed around cavities made by birds in the soft outer tissues.

THE PLANT WORLD

A Magazine of General Botany

MAY, 1908

ACROSS PAPAGUERIA.

DANIEL TREMBLY MACDOUGAL.

An immense flattish ridge slopes from elevations of 3000 to 4000 feet in southeastern Arizona, 300 miles westward to the delta of the Colorado river and the upper part of the Gulf of California. A score of mountain ranges including the Whetstones, Santa Ritas, Santa Catalinas, Tortolitas, Sierritas, Tucsons, Carobabis, Baboquiviris, Quijotoas, Ajos, Growlers, Rincons, Dragoons, Mohawks, Gilas, Tulec, Lechuguillas, Maricopas, Ciprianos, San Franciscos, and San Rosarios, run transversely across the ridge with crests that rise to over 9000 feet in some instances, the intervening valleys being for the most part broad flattish troughs with undeveloped drainage opening to the northward into the Gila river and to the southward to the Altar and Sonoyta rivers in Sonora.

The area of several thousand square miles included, might be properly termed the northernmost extension of the desert which extends southward along the Pacific coast to the Isthmus of Tehuantepec. The precipitation is less than a dozen inches except on the higher summits, the greater part of the yearly rainfall coming in midwinter and midsummer. Temperatures of 118° and 120° F. have been recorded in the lower levels, some places showing a daily maximum above 100° F. during portions of six months of every year. The possible evaporation that would ensue from a water surface would probably be between 80 and 100 inches per year, or about six to eight times the precipitation. The general

aspect of the vegetation is highly xerophytic although of some abundance. An analysis of the flora, however, shows that a large proportion of it, as in all western American deserts, is made up of annuals and perennials which are active only during the periods of maximum precipitation in summer and winter. These forms do not exhibit any structures which distinguish them from mesophytic species of moister regions, but they show peculiar rhythms and dormancies. The seeds of many of the winter annuals will germinate only in the low temperatures of the winter months, lying wholly inactive during the summer rains, while the summer annuals are equally unaffected by the moisture and stimulus of change of the cooler months. As a result of the arrangements in question, the vegetation shows an intricate interlocking of temperate and sub-tropical forms with, of course, a very large number of endemic species of both classes. Legumes are abundant and are represented by a great number of species. Most remarkable of all however, are the cacti, comprising a group of forms of comparatively modern origin, and including hundreds of species, some of which are extremely restricted in distribution.

The area in question is of increased interest since its inhabitants include the Papago Indians, a desert race that was differentiated from the Piman stock, and these bean-growing farmers have lived here in adjustment to the arid conditions for ten or twelve centuries and are at present but little disturbed by the civilization of the white race, although the most meaningless international boundary in the world cuts diagonally across their domain, which was designated as Papagueria by the earlier Spanish explorers. They still dominate the country as a whole, and the relations of their activity to the climate and to the other living forms are as interesting biologically as anything to be found in any undisturbed area.

The work of the naturalists of the boundary survey commission after the Gadsden purchase, made an unmeaning

western slopes of the Pinacate volcanoes near the Gulf of California. Upon returning, the route was laid almost due northward from Sonoyta to the Gila river, thus sectioning the great ridge at right angles. The results in detail will form the subject of an extended paper now in preparation, but some of the prominent features of the vegetation may be discussed here with profit.

The sahuaro, or giant cactus (*Cereus giganteus*) is probably the most prominent by usefulness and obtrusiveness of all the striking forms that inhabit the desert land of the Papagoes. It ranges from the Tonto basin in central Arizona westward to the Colorado river, which it crosses to occupy a small area in California in the vicinity of the mouth of the Bill Williams river. It extends to the eastward to the drainage of the San Pedro river and southward in Sonora to the latitude of Guaymas, its exact limit not being determined, and follows close to the Gulf up to its head. In the northern portion of its range, it occupies sunny slopes at an elevation of 4000 feet and it descends into some of the old craters of the Pinacate volcanoes to a point but little above the sea-level, climbing the main peak nearby to the maximum elevation. As the limits of the range of the sahuaro are approached, branching becomes less profuse and the outlying individuals show simply columnar trunks, usually bearing some marks of the stress under which they exist. In more favorable localities an unending variety of grotesquely arranged branches are to be seen and secondary branches are exhibited in some instances. Native guides are given to informing travellers, with apparent sincerity, that the branches are in reality separate plants which have risen from seeds deposited in cracks of the trunk by woodpeckers and other birds. It has been pointed out recently (Turrell, C. A., Univ. of Ariz. Monthly, Jan. 1908,) that the common name of this great cactus (*Cereus giganteus*) must have been a Castilian rendering of an ancient name in use when the Spanish explorers first came, and as the use

of the *g* with the sound of *w* was unknown, the proper spelling of the name of this plant would be "sahuaro" instead of "saguaro".

The number of seedlings and young plants of the sahuaro which may be found by ordinary methods of observation, is very small, but the great valley lying between the

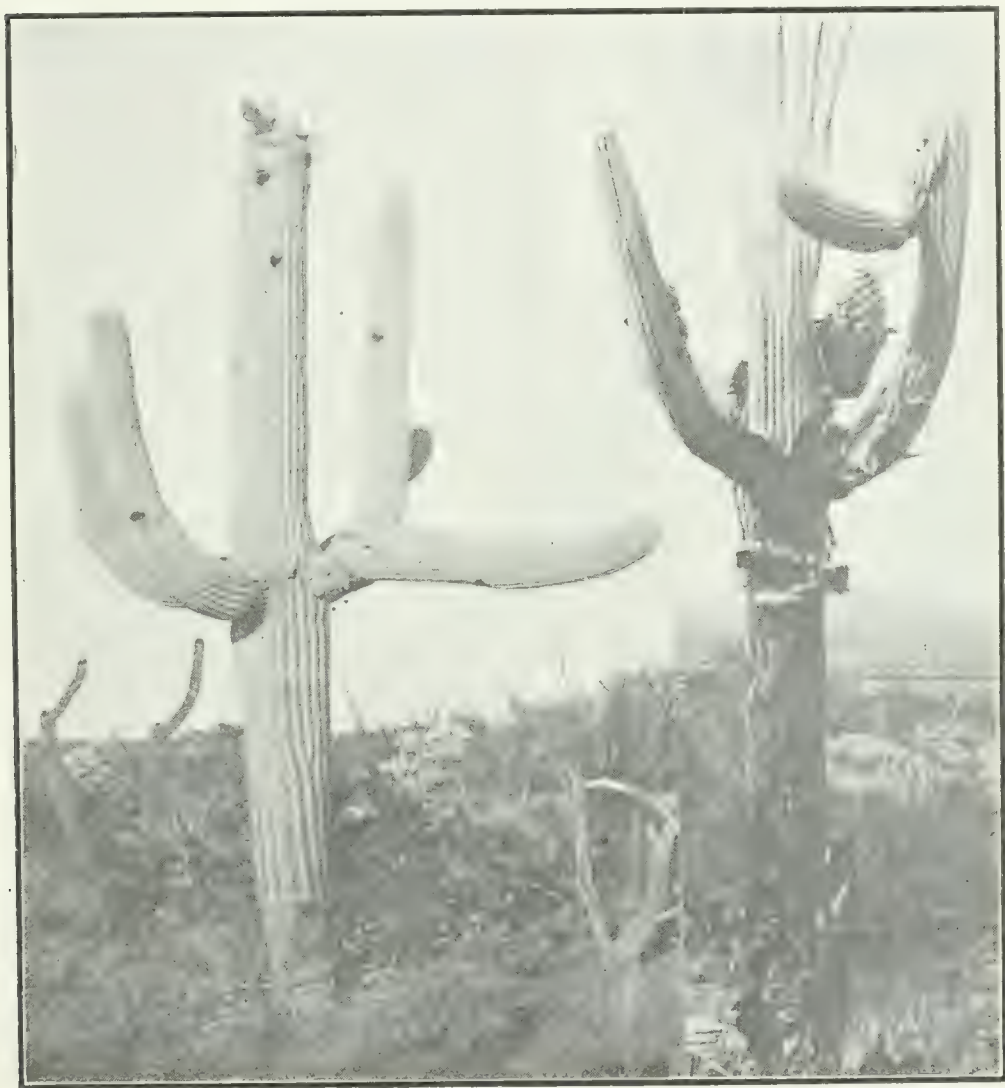


FIG. 2.—Sahuaro from the summit of which a prickly pear is growing and a second which has been dead fourteen months with one branch still living. A callus pouch is to be seen on the lower part of the stem.

Carobabi and Quijotoa mountains, was found to be densely inhabited by this plant, represented by individuals in all stages of development, the plantlets being so numerous in places as to form clumps.

It would be difficult to estimate exactly the importance of the sahuaro to the animal life of the area which it inhabits. Its flowers opening in May and June offer food and shelter to countless swarms of small bees and gnats. The ripening fruits furnish a profusion of seeds and a wealth of sweetish pulp to birds and small mammals, while the Indian makes use of both portions of the fruit, fresh, fermented and preserved. Scores of tribal battles have been fought in Papagueria over the sahuaro harvest. The seeds which reach the ground quickly germinate in the baking soil, and the tiny capsules of acid water stored in the plump spineless hypocotyl constitute a most attractive morsel for thirsty and hungry animals, and not one seedling in a million survives the first year in consequence. The bases of large plants are stripped and gnawed by rabbits and hares in the southern portion of the habitat, while the carpentarios, or woodpeckers bore huge cavities into the soft outer tissue which are quickly lined with a callus formation, forming a fine nest cavity. These cavities also offer storage room and shelter for swarms of honey bees. With so many animals making use of its fleshy trunk and branches, the greater number of the sahuaros perish before reaching a height of forty feet. The central pith and the thick outer cylinder of pulp quickly decay leaving a fascicle of woody rods which anastomose in the older lower portions but which are free in the upper terminal parts. The callus bags developed around the cavities made by birds also resist decay and may be seen hanging to various parts of the woody skeleton. Decay generally begins in the lower part of the trunk which goes to pieces first, with the result that some of the upper branches retain their form and normal appearance for many months while attached to a naked skeleton high up in the air and separated from any available supply of water by many feet. The illustration given in Fig. 2, shows such a living green branch which has maintained an independent existence on the dead skeleton for about 14 months.

The wood of the sahuaro yields a light and strong building material much used by the Papagoes in making the picketed walls of their jacails or in making barriers around small gardens or corrals. Illustrations of such cases are to be seen in the city of Tucson. Recently Mr. Fred. C. Wright has discovered a process of dehydration and tanning that will greatly increase the usefulness of the sahuaro. This process is described by him in a separate article in this number.

A very remarkable instance of pseudo-parasitism was found in a large specimen of the sahuaro in the Quijotoa valley during the course of the expedition. An *Opuntia* with three main branches was seen growing from cavities at the apex of a large tree which was otherwise normal in appearance. Seeds of the *Opuntia* had probably been carried to the summit of the sahuaro and germinating in one of the cavities, had found a suitable substratum in the decayed material which had formed there.

Similar attachments to other plants have been observed; a prickly pear near the Desert Laboratory is rooted in a knot hole of a palo-verde (*Parkinsonia microphylla*) and a large *Opuntia* was seen growing from the sinus of a stem of *Yucca valida* near Tehuacan in southern Mexico. Prof. W. L. Tower reports that such arrangements are by no means uncommon still further to the southward.

(CONCLUDED IN JUNE NUMBER.)

LEATHER FROM CACTI: SOMETHING NEW.

By FREDERICK C. WRIGHT.

One day, over a year ago, the writer, while handling a piece of bisnaga (*Echinocactus wislizeni*) noticed, after the water it contained was pressed from the fiber, its remarkable strength and pliability, and resemblance to leather. Upon drying it became brittle and chalklike.

In an effort to obtain strength and pliability in the fiber after drying, I began a series of experiments in a crude

way, not being a scientist nor a chemist, and unfamiliar with their methods. I boiled the fiber with mesquite bark and burnt rags to tan and color it. I secured the color but the fiber did not tan. I soaked it in oil; I used aluminum palmitate, tannic acid, gum arabic, caoutchouc, and I used glue, but none of these gave results. But, late one night soon after, I went to bed and slept the sleep of contentment, with a piece of perfect leather made from cactus fiber in my hand. I used water and glycerine, about twenty-five per cent of the latter. All these things, after one knows them, are as simple as spreading butter on bread. But, of course, it's the finding out that's so difficult.

After I learned how simple it was to make the cactus leather, I then experimented to discover the best methods of cutting and drying. On account of the large proportion of water contained in a bisnaga or sahuaro, the thickness of the fiber reduces remarkably during the drying process. If the fiber is cut one-half inch thick it reduces to about one-sixteenth of an inch in thickness; yet, one cannot cut the sheets so thin that there is not a film of leather left when the fiber is dry.

The final finish depends on the manner in which the cut has been made, with knife or saw, as well as the direction of the cut. The grain of a sahuaro or bisnaga runs crosswise the cactus, or, more properly speaking, it runs from the heart of the cactus to the outer edge, with rows of tougher fiber extending to the center of each corrugation that forms the support for thousands of needle-like spines.

Leather made from a cross-grain cut is not so strong as that made from fiber cut with the grain. The width and length of a sheet of cactus leather need be limited only to the length and diameter of the cactus, and the facilities for cutting.

If a circumferential cut is made (as one would peel an apple) from twenty to forty feet in length of fiber may be obtained from cacti of the larger growths. In making the

circumferential cut, the length of the sheet, of course, is also governed by the thickness of the sheet. If it is a half-inch cut a good sized sahuaro will give over twenty feet in length of fiber. By making the sheet one-quarter inch thick, close on to fifty feet of film may be obtained, according to the diameter of the cactus.



FIG. 3.—Articles made from cacti. F. and G. leather from the parenchyma of the bisnaga (*Echinocactus*); H. belt of parenchyma of the sahuaro (*Cereus giganteus*): Flattened longitudinal section of sahuaro including several ribs held together by a tanned layer of parenchyma; N. pincushion made from a cross section of a sahuaro stem: shallow vessel with a bottom of tanned parenchyma and sides of short portions of attached ribs of the sahuaro.

Immediately after cutting the fiber is placed direct in the tanning bath. The tanning process requires from two to three hours, according to the thickness of the fiber. After removal from the bath the fiber is limp and has great weight. Large pieces must be handled with some care lest they be torn. However by cutting and tanning the fiber in a thin sheet and reinforcing with cloth of some other suitable

material, and by using a gloss finish the brittleness is overcome and great strength is secured.

The drying process is the most tedious of all. As much water as possible is first pressed from the sheet, after which it may be hung up to dry, or dried by artificial heat. When dry the leather is white or tan, and may be stained any color desired.

Leather may also be made from the leaves of the opuntia, the older joints only being used for the purpose.

The covering of spines and epidermis are removed, leaving the tough, wirelike fiber which grows just inside the outer covering. A sheet is placed in the tanning bath for two hours or more, then removed and dried. A remarkable feature in this instance, is the fact that nature's coloring is preserved in the leather if properly tanned.

In conclusion—many small articles may be made from the heart of the sahuaro, such as baskets, boxes, picture-frames and numerous other objects of use and decoration.

The entire trunk of this giant which reaches a height of 40 to 75 feet and a maximum diameter of two feet, may be utilized in the manner described, and, as the sahuaro covers an area of 120,000 square miles in Arizona and Sonora, no lack of raw material will be encountered in the application of this method of preparation.

TUCSON, ARIZONA, March 9, 1908.

PERIODICITY IN THE FRUITING OF A MARINE ALGA.

W. D. HOYT.

Dictyota dichotoma is a brown alga with a flat, forked, ribbon-like thallus common on portions of our coast from North Carolina to Florida (Fig. 4.) It bears three kinds of reproductive bodies—tetraspores (asexual) and eggs and spermatozoids (sexual)—each plant bearing only

one kind of these reproductive cells. The rudiments of the tetraspores are borne singly or in small groups, while the eggs and spermatozoids are produced in sori—appearing, when mature, as black or white patches distinctly visible to the naked eye. The tetraspores are produced without regularity, spores of all ages being found on the same plant at any time during the fruiting season.

In some localities the sexual cells, however, show a remarkable periodicity in their production, appearing in regular crops at definite intervals—all the eggs and spermato-



FIG. 4.—Male and female plants of *Dictyota dichotoma* showing the fruits in patches on the surface. About one-fourth size. This photograph is the property of the Bureau of Fisheries and is published with the permission of Hon. George M. Bowers, U. S. Fish Commissioner.

zoids on all the plants in the same locality being, at any one time, at about the same stage of development. These crops follow one another in regular succession and bear a definite relation to the spring tides.

The spring tides are, of course, those of greatest range, having the highest floods and the lowest ebbs, and occur every two weeks, about the times of the new and the full moons. The neap tides are those of least range, having the

lowest floods and the highest ebbs, and occur between the springs.

This periodicity in the fruiting of *Dictyota* was first described by J. Lloyd Williams. According to this author, (1) the sexual plants of *Dictyota* on the coast of Wales and England fruit at fortnightly intervals, the sexual cells, on the coast of Wales, being initiated a few tides below the least neap and liberated a few tides after the greatest spring tide. Williams concluded, from careful observations, that the factor regulating this periodicity is the increased amount of light obtained by the plants during the low water of spring tides.

Observations made at the laboratory of the Bureau of Fisheries at Beaufort, North Carolina, during the past two summers show that, at this place also, *Dictyota dichotoma* produces its sexual cells in regular crops bearing a definite relation to the tides. These crops are, however, borne at monthly, instead of fortnightly intervals, appearing only at alternate spring tides. Rudiments of sexual organs are first observed about the day of the greatest tide, and general liberation of the sexual cells regularly occur on the sixth day after the greatest tide of each alternate set of springs. ²

This succession of crops occurs with the utmost regularity throughout the summer and is very exactly associated with the range of tides given in the tide tables of the United States Coast and Geodetic Survey. This association is so exact that it was possible, at the beginning of last summer, to predict accurately the stage in the development of the sexual cells which the Beaufort plants of *Dictyota* would show on every day during the entire season. Until one has seen rudiments of sexual cells appear on practically all the sexual plants on the same day, has watched this crop pass rapidly to maturity, has seen the discharge of the eggs and

1. *Annals of Botany*, 19: 531-560, 1905.

2. The author is indebted to Hon. George M. Bowers, U. S. Fish Commissioner, for the privilege of working in the Fisheries Laboratory at Beaufort, North Carolina.

spermatozoids on the morning of the sixth day after the greatest tide, and then has seen crop after crop follow one another in regular order on corresponding days during each alternate set of spring tides, one can scarcely realize the striking nature of the phenomenon.

A fuller account of the fruiting of *Dictyota* at Beaufort with a chart showing the relations of the fruiting periods to the tides may be found in the Botanical Gazette for June, 1907.¹

It is not possible, with our present knowledge, to explain this periodicity or the differences exhibited in different localities. The time of production of the crops at Beaufort is very exactly related to the range of the tides given in the tide tables, but does not seem to be affected by the actual height of the water, or by the number of days intervening between the spring tides. Experiments made by the author show that the periodicity is transmitted to new portions of the thallus produced under conditions removed from the influence of the tides.

A few observations indicate the possibility that plants of *Dictyota dichotoma* growing a few miles from Beaufort may fruit with a periodicity slightly different from that of the plants at Beaufort. We do not know whether these differences, if they are constant, are to be explained by differences in the environment or by some other factor—for example, geographical isolation.

Specimens of several species of *Dictyota* from three localities in Jamaica indicate that a modified periodicity obtains there; while all the sexual cells on one plant were of one age (or of two very distinct ages), the sexual cells on different plants were of different ages. Further study is needed, however, before we can form conclusions about the fruiting plants of this region.

Our knowledge of this entire subject is very scanty. Much work remains to be done. We should discover whether

1. Botanical Gazette 43: 383-392. 1907.

plants of the same species in adjoining regions fruit at the same or at different periods; and if at different periods, whether the time of fruiting can be correlated with any conditions of the environment. We should determine to what extent periodicity is shown by other species of this genus and by some genera of the Dictyotaceæ, with the nature of this periodicity, if it exists. It is greatly to be desired that someone should study, from this point of view, the species of *Dictyota* occurring on the Pacific coast. All such data will help to answer the important question, whether this phenomenon is a very exact reaction to periodic factors in the environment, or whether it is an expression of an inherent tendency of the plant, more or less independent of external conditions.

It is hoped that this account will indicate the interesting nature of the problems involved in this line of investigation, and the great need for more data, and will induce other botanists who are favorably situated to begin a study of this alga. It seems that only by careful observation of the fruiting and by comparison of the conditions at a number of places for a considerable time can we hope to understand the striking phenomenon described. The author will be glad to correspond with anyone who is interested in this problem.

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EVAPORATION AND CENTERS OF PLANT DISTRIBUTION.

By BURTON EDWARD LIVINGSTON.

In two previous papers¹ attention has been called to the effect produced by the evaporating power of the air upon the growth of certain plants rooted in a constantly moist soil, and to the marked influence which evaporation appears to

¹ Livingston, B. E., Evaporation and plant development. *Plant World* December, 1907.

Evaporation and plant habitats. *Plant World*. Jan., 1908.

exert in determining what species will occupy different habitats. The first paper emphasized the physiological effect of an atmosphere of excessively great evaporating power, and pointed out that certain plant forms are definitely influenced by this climatic factor, independently of the secondary effect which this factor undoubtedly exerts through variations in the soil moisture conditions. The second paper dealt with evaporation as an ecological or edaphic factor, and pointed out the great variations in the evaporating power of the air in different habitats of the same region. In the present paper the geographical feature of evaporation will be considered.

The secondary effect of evaporation, in determining, in a large measure, the moisture content of the soil, is perhaps usually a more important factor in plant distribution than is the primary effect upon the plant itself. In any event, the optimum condition for growth, as far as moisture conditions are concerned, is to be considered as a certain balanced relation between the supply of water which the soil can furnish and the evaporating power of the air. Furthermore, climatic evaporation is influenced by temperature, humidity, and wind velocity, all of which are known to be very efficient in the control of plant activities. The evaporation, therefore, would be expected to play an important role in the determination of the great regions of plant distribution, as well as in the distribution of societies within the same region.

The importance of considering the rainfall in studies in plant geography has long been recognized, but the importance of evaporation in such studies has met with but very tardy appreciation, a fact partly due, no doubt, to the lack of satisfactory evaporation records. Thus far Transeau has furnished the only real evidence at hand in regard to the relation of geographic distribution to evaporation. In his paper on this subject² attention is called to the fact that

2. Transeau, E. N., *Forests of Eastern America*. Amer. Nat. 39: 875
1905

the ratios of rainfall to evaporation furnish a compound climatic factor which is more satisfactory in explaining the distribution of the forests of eastern North America, than is either rainfall or temperature taken alone. The paper is accompanied by several very instructive charts, showing an excellent agreement between the precipitation-evaporation ratios, on the one hand and the limits of the three great forest centers of the region, on the other.

The evaporation data on which Transeau's work is based are somewhat unsatisfactory, having been calculated by Russell³, from the readings of whirled, wet and dry thermometers, taken in the instrument shelters of the U. S. Weather Bureau. It was therefore deemed worth while to attempt a series of direct observations of evaporation, with an instrument which would simulate, to as great an extent as possible, the position and condition of living plants, and to test the value of evaporation alone as a criterion for relating plant distribution to climatology. The porous cup atmometer, described in the first paper cited above, was used for this purpose. Instruments were sent to twenty-four stations in the United States, and were read weekly by observers at the several stations, for a period extending from the middle of May 'till the end of September, 1907. There was some variation in the time at which the instruments were installed, but nearly all were in operation by June 1, and continued to the end of the period. The evaporating cup was placed in the open, with its center fifteen centimeters above the ground, so that the records may be taken to represent the evaporation conditions which are met by a plant of about the above named height, growing in the open.

Before the instruments were sent out to the stations they were assembled and carefully compared, and coefficients of correction were determined for all of them, thus making it possible to reduce the readings to standard. Unfortunately,

³ Russell, T., Depth of Evaporation in the United States. Month Weath. Rev. 16: 225-239. 1888.

as it afterwards developed, the water used in this standardization was impure, so that the standard cup gradually became clogged, and the coefficients then obtained were in many cases incorrect. At the end of the season, however, the cups were returned to the Desert Laboratory, and there restandardized. The new correction coefficients thus obtained are the ones used for the results here to be given, with the exception of a few instruments which were received in bad order or not returned at all. For these instruments the old coefficients have been used.

The results obtained from the season's records are only partially satisfactory, for several reasons besides the trouble with the standardization, already mentioned. Some of the observations were not continued throughout the entire period; gaps occurred in some of the series, due to accidents; several cups could not be restandardized, for one reason and another, and the original selection of localities for the stations was found to be inadequate to represent the areas occupied by the vegetational centers. Atmometers placed in regions intermediate between those of vegetational centers gave data as difficult to analyze as are the vegetational characters of such regions. It is planned to continue this inquiry through another growing season, with a larger series of more carefully placed stations.

Following is a table of the data from sixteen stations. The data for the other stations in the original series are untrustworthy, on account of incompleteness or for other reasons. In the table are represented four partial periods, corresponding roughly to the months, June, July, August and September. The first period comprises four weeks, the second four, the third five, and the last four. In the first column of the table are given the name of the station and that of the observer. The four following columns present the averages of the weekly losses for the four monthly periods, respectively. These rates are in cubic centimeters, and are to be considered only as *relative measures* of the

evaporating power of the air. In the last column are similar averages of the weekly losses from the instruments, for the entire period of seventeen weeks. The stations are arranged in the order of the magnitude of the quantities in the last column. All these data may be reduced to millimeters of depth of evaporation from a free water surface, by dividing each by the number 6, for it was found that a loss of six cubic centimeters from this instrument corresponds, approximately, to a loss of one millimeter evaporated from an open vessel.

Relative Evaporating Power of the Air at 16 Stations in the United States, June 3, to September 30, 1907.

Station and Observer	June	July	Aug.	Sept.	Av'rage
Mecca, Calif., Mr. B. G. Johnson	349	368	303	278	323
Laramie, Wyoming, Prof. Aven Nelson	322	311	286	274	298
Tucson, Arizona, Dr. W. B. McCallum	338	228	212	282	262
Salt Lake City, Utah, Dr. I. D. Cardiff	92	285	272	227	222
Austin, Texas, Prof. W. L. Bray and Mr. Beck	225	166	168	215	192
Raleigh, N. C., Dr. F. L. Stevens	120	188	269	151	158
Eugene, Oregon, Prof. J. R. Sweetser	90	196	208	98	152
Gainesville, Fla., Prof. P. H. Rolfs		133	169	122	*143
St. Louis, Mo., Dr. Wm. Trelease & Mr. Henri Hus.	112	157	140	137	137
Burlington, Vermont, Prof. L. R. Jones and Mr. F. V. Rand	120	130	132	63	112
Lincoln, Nebraska, Prof. F. E. Clements & Mr. Loveland	96	90	113	144	111
Chicago, Illinois, Dr. G. H. Jensen	93	95	109	95	98
Orono, Maine, Prof. W. J. Morse	81	91	96	67	84
Newark, Delaware, Prof. Mel. T. Cook	98	97	77	63	83
Grand Rapids, Michigan, Miss J. D. Livingston	70	82	105	54	79
New York City, Dr. C. S. Gager	-	48	63	35	*50

* Average for 13 weeks instead of 17.

From the table it is seen at a glance that the evaporating power of the air was much greater in the arid Southwest than in any other portion of the region under observation. It is also evident that the stations exhibiting the least evaporation are on the Great Lakes or Atlantic Seaboard. A number

of stations present puzzling problems, which may be cleared up with the accession of more data.

An attempt may now be made to relate the evaporation data here given to the regions of forest centers as given on Transeau's charts. The northeastern conifer forest extends from the southern end of Lake Michigan to Nova Scotia, roughly occupying the valley of the Great Lakes and the St. Lawrence river. In our series, this region is represented by Chicago, Grand Rapids, Burlington, and Orono, four stations which agree fairly well in their average weekly evaporation rates. If we determine the average of these four rates, namely 95, 78, 111, and 84, we obtain 93 as the average weekly evaporation rate for the entire region of the northeastern conifers.

The deciduous forest center occupies a region south of the conifer center, reaching from St. Louis to New York City, and extending westward, southward and northward from this line. None of our stations are well located for a study of the conditions obtaining in this center, but four of them are situated near its border, these being St. Louis (137), New York City (49), Newark (84), and Raleigh (157). The average of the rates for these four stations is 107, which perhaps approaches the average evaporation rate for the deciduous forest center.

The desert center of the Southwest is well represented by Mecca (325), Tucson (265), and Salt Lake City (219), which give an average rate for this region of 266.

The only station in the southeastern conifer center is Gainesville, with an evaporation rate for the season of 141. Much stress must not be laid on this single record. Likewise in the prairie center we have but one well placed station, Lincoln, with a rate of 111. Austin seems to exhibit an evaporation rate between that of the desert center and that of the deciduous forest, and its location would seem to support this view.

If we assume, as unity, the evaporating power of the air, in summer, over the northeastern center, then the index of evaporation for the deciduous forest becomes 1.15, and that for the desert becomes 2.86. On Transeau's map the northeastern center appears to be represented by a precipitation-evaporation ratio of about 1.25, while the deciduous forest is represented by a ratio of about 1.05. From the western portion of the map it is apparent that the desert ratio of the Southwest, must approximate 0.30. For the three regions our indices are: 93, 107, and 266, while Transeau's ratios are: 1.25, 1.05, and 0.30. An inspection of these numbers brings out the fact that they represent two very similar series, and that the indices are approximately inversely proportional to the ratios. That is, we have:

$$1.25 : 1.05 = 1.15 : 1.00, \text{ or } 1.25 = .97$$

$$1.25 : 0.30 = 2.86 : 1.00, \text{ or } 1.25 = .68$$

When it is remembered that Transeau dealt with the evaporation rate for the entire year and that we have considered it only for the summer, the condition of agreement between the two methods must be regarded as very satisfactory. It would thus appear that, as far as the present data are to be relied upon, the summer evaporating power of the atmosphere seems to offer as satisfactory a criterion for relating these three vegetational centers to climatic factors as do the precipitation ratios of Transeau. In this connection it is to be remembered that, generally, evaporation is a complex factor, including effects of temperature, humidity, wind velocity, rainfall, barometric pressure, and even light intensity. It thus furnishes a rather satisfactory automatic summation of all the climatic factors which affect the activities of plants. For details of distribution, temperature, precipitation, light intensity, etc., will undoubtedly have so kindly attended to the records of the atmometers at the region and of the plant forms involved.

I wish to express here my thanks to the observers who have so kindly attended to the records of the atmometers at the several stations. Without their interest and aid this study could not have been undertaken.

Munich, March 26, 1908.

ACCLIMATIZATION OF PLANTS AT DEL MONTE, CALIFORNIA.

However much we may credit the plant with power to adapt itself to strange surroundings, or with ability to dodge the climatic question, the fact remains that the natural habitats of the introduced plants at Del Monte are the most diverse possible, and that many of them are also very different from the climate at Del Monte itself. The following few illustrations will show the extremes in habitat conditions:

Pinus sylvestris occurs in Europe as far north as latitude 68° . At latitude $67^{\circ} 34'$, Verkhyansk, Siberia, the yearly extremes of temperature are from -79.6° in winter to 86° F. in summer. This is an annual range in temperature of 165.6° F. Probably the opposite extreme is to be found in the habitats of plants of the deserts, as, for instance, that of the date palm, or that of the Washington palm. One station of the former is at Biskra in the Sahara, where the winter temperature goes to 43° F. and the summer temperature reaches 105° F. The Washington palm is native in the Colorado desert of our own country, where the annual extremes in temperature are from 43° F. to 112° F. The annual extremes in temperature at Del Monte are not available, but those at San Francisco, 100 miles distant, are from 39° F. in winter to 98° F. in summer. The variation in the annual rainfall of the habitats represented is quite as striking. It ranges from 2.97 inches in the Colorado desert to 92.58 inches in the Puget Sound region; and probably the precipitation in the Himalayas, the home of *Cedrus deodara*, is even greater. The annual rainfall at Del Monte is given at 14 inches, but the proximity of the ocean so reduces natural evaporation that this small amount is probably the equivalent of a much greater precipitation farther inland.

In the cases of most of the introduced plants growing in the open at Del Monte, it is probably true that the native environments lie well within the extremes given for the palms and the pine in the preceding paragraph.

Should we analyze the relation of the activity of these plants in their native habitats to the changes in climatic conditions of the habitats, we would expect to find that the period of greatest growth, or of flowering, would coincide with the most favoring portion of the year. During the least favorable seasons the plants would probably all be in a dormant condition. And we should expect to find that, on the average, the early conditions at Del Monte would not be very far removed from these same most favoring seasons. Without entering further into the subject in this place, therefore, we may conclude that at least a leading reason, aside from the inherent variability of the plants, why so great a variety of plants from so extreme types of natural habitats can be grown successfully out-of-doors at Del Monte, as well as other places on the Coast, lies chiefly in the fact that the average plant conditions are very much like the most favorable conditions in the habitats from which the introduced plants were taken.—W. A. Cannon in *OUT WEST* for May, 1908.

MINOR ARTICLES AND NOTES.

The Harpswell Laboratory at South Harpswell, Maine, will be open from June 5th to September 15th.

Prof. F. D. Heald has resigned his position in the University of Nebraska to accept the Professorship of Botany in the University of Texas. The double position held by Dr. Heald in the University of Nebraska has not yet been filled.

The MacMillan Co., of New York, have recently issued *The Origin of Land Flora*, by Prof. F. O. Bower. (\$5.50 net.)

This may be regarded as one of the most important works on general morphology that has appeared within recent years.

and it presents the aspect of biology and relationship as based upon morphology and form. The relation of experimental methods to morphology is very clearly set forth. The book will rank as a classic.

Unfamiliarity with linotype has resulted in some grave errors in the March and April numbers of the PLANT WORLD. Among the more serious are those by which Prof. H. S. Conard's signature to the article on "Acres of Liverworts" in the March number was made to read "Henry S. Conrad" and that of Dr. Mac Dougal in the April number was printed as "MacDoural," while Professor Setchell's name was spelled "Setshell."

The annual announcement of the Marine Biological Laboratory at Wood's Hole states that Dr. G. T. Moore, Prof. B. M. Duggar, Prof. H. Kraemer, Prof. M. B. Thomas, Dr. H. Von Schrenk, Dr. E. F. Smith, Prof. J. M. Coulter, Prof. G. R. Lyman, Dr. C. J. Chamberlain, Mr. R. R. Gates and Mr. C. H. Shattuck will participate in the work of the department of Botany during the summer. Correspondence should be addressed to Dr. G. T. Moore, at Watermill, N. Y., until the beginning of the session on June 1st. The work for the season closes on August 11th.

There will be held in the Olympia Hall, London, England, September 14th. to 26th. of this year, an International Rubber and Allied Trades Exhibition. The following committee has been appointed to take charge of Mexican matters: Pehr Olsson-Seffer, Chairman; I. Carranza, Editor "El Heraldo Agricola"; O. H. Harrison, President, Rubber Planters' Association of Mexico; J. C. Harvey, Vice-President, Rubber Planters' Association of Mexico; F. E. Lloyd, Guayule Experiment Station, Zacatecas; W. B. Murray, Editor "Mexican Investor," Secretary Rubbers Planters' Association of Mexico; Col. J. B. Sanborn. The above committee constitutes a portion of the Official Advisory Committee of the Exhibition in London.

Professor Goebel's twenty-fifth Anniversary. On Saturday evening, March 7, was celebrated in Munich the twenty-fifth anniversary of Professor K. Goebel's appointment as professor, an occasion on which some fifty botanists were presents at a banquet given him by his colleagues and students. Among the well-known scientists present were:—Wettstein, of Vienna; Lotsy, of Leiden; Giesenhagen, of Munich; Glueck, of Heidelberg; Tubeuf, of Munich; Hildner, of Munich; Raciborsky, of Lemberg; Karsten, of Bonn; Loew, formerly of Tokio; Hertwig, of Munich; Doflein, of Munich; Rothpletz, of Munich and Andrews of the University of Indiana. Prof. Goebel was first elected to a professorship in Rostock, later occupied a professorship in Marburg, and came to Munich in 1896. At the banquet, he was presented with a Diploma of Honor by Prof. Wettstein, for the Association Internationale des Botanistes. His former students presented him with a memorial album, and announcements were made of his election as honorary member of the University at Kiew and also of the Naturforscher-Gesellschaft of St. Petersburg. Numerous telegrams of congratulation by former students and colleagues coming from many botanical centers in Europe and including one from Tokio were received. After the banquet those present attended a celebration in Prof. Goebel's honor, given by the Akademischer Pharmaceutenverein.

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DISTRIBUTIONAL FEATURES OF SOME SOUTHWESTERN SHRUBS.

BY J. C. BLUMER.

Certain shrubs of the southwestern United States exhibit distributional features of great interest. Several species have been observed to change their topographic location, and especially their aspect or slope exposure, with altitude.

Chief among these may be mentioned *Lippia wrightii* A. Gray, one of those plants that are widely distributed geographically, but far from covering extensive areas in any one locality, are usually found in small numbers only, fitting snugly into their own special habitat. This little suffrutescent shrub, richly scented, pointed out to the writer by Mr. Thos. J. Riggs, of San Simon, Arizona, as a producer of excellent honey, was first seen under rocks that jutted from the northern base of the Chiricahua Mountains into the San Simon Valley as a promontory looks into the sea. The elevation of this point is a little below that of old Fort Bowie, a few miles to the westward, or not far from 3500 feet above sea-level. It was later noted at Paradise, situated at 5400 feet in the same mountain range, on sunny rocks bordering Walker Creek, and on bouldery bluffs along Cave Creek, at about the same elevation, both places of southerly exposure, or opposite to that of the Fort Bowie station. At Paradise it does not grow on the opposite side of the creek. It was then noted for half a dozen more localities about the lower altitudes of the Chiricahuas, extending from old Fort Bowie to College Peak, each time on rocky declivities. In two

places, both at an altitude of between 5000 and 6000 feet, the species was recorded as occupying a southerly aspect.

In covering the interval between the Chiricahua Mountains and Tucson, it was seen but once on each of two routes, viz.: clinging to gravelly banks of arroyos, between Mescal and Pantano, on the Southern Pacific Railroad, and filling the interstices between blocks of bedrock sloping toward Nugent's Pass where this breaks through the Caliuero Mountains into the San Pedro Valley. It occurs on similar habitats in Sabiño and Ventano Canyons in the Santa Catalina Range, and one mile up the latter canyon it has been noted growing on a steep north slope, under rocks, at probably 3500 feet. In the Tucson mountains it has been met once on Quijotoa road, keeping close under a wash bank, facing north, and again in the narrow, well-protected defile on the north side of Mount Tucson, filling spaces between large rocks; neither place has much over 3000 feet elevation. On Tumamoc Hill it grows as considerable colonies only in the best protected places of steep, northerly aspect, between the contours of 2500 and 3100 feet. It has not been found on the south side of the hill, and if present at all, must be exceedingly rare.

In following a third route eastward between Tucson and the Chiricahuas, the species in question was first seen on the pebbly bank of an arroyo where first the surface begins to rise perceptibly toward the Santa Rita Mountains. The altitude here is not far from 4000 feet, and the *Lippia* still grew on a bank facing northward. It was not encountered again until reaching the southern foothills of the Mustang Mountains, where it bordered sparingly a gully at 5000 feet, apparently not particular as to aspect. In the San Pedro Valley it made its first appearance four miles east of Fairbank, fringing the steep sides of a gravel run, and a second, six miles east, on the river bluffs, composed of similar coarse material. Again, it occurred on the peculiar erosion area some two or three miles west of Tombstone, clinging in

occasional clusters to the rockiest places. Next, on the southern extension of the Turquoise Hills a mile east of Gleeson, at about 4800 feet, it grew on any rocky exposure. Crossing the Sulphur Springs Valley and the Swisshelm Mountains it was met but once near their eastern base, at about 5700 feet, this time on a steep southerly aspect. Reaching the southern Chiricahuas again, it was seen at approximately 5000 feet to cling to rocky nooks on both sides of the narrow Hunsaker Gulch, with little regard to aspect.

In the vicinity of Paradise, this shrub was again found, this time in considerable numbers, on the steep and pebbly banks about the head of Silver Creek. Following certain indications that here promised its ascent to unusually high elevations, and wishing to ascertain its aspect relations near its upper altitudinal limit, it was looked for and found on the top of Maxon's Peak, at 6100 feet, and on the summits of the two peaks immediately north of Portal at 6350 and 6500 feet, respectively, in each case fully exposed to sun and wind. It was common on a south slope faced with great blocks of limestone 1000 feet below the higher summit. Two hundred feet below the latter a ridge running east and west was examined with the result that it was found present on the south and absent on the north side. On Mt. Desert it attained to within 100 feet of the summit which lay at 6250, on the south and southwest sides, but was absent from all other sides. Finally, the crest of a chain of hills just north of Paradise, rising toward the main axis of the range, was followed, with the result that *Lippia wrightii* was found very sparingly two or three times, each time on rocky, exposed places facing southerly, while on north or any other aspects it was looked for in vain. The highest station found lay on an exposed ridge sloping sharply to the south, at an elevation of 6600 feet above sea level. This is within 100 feet of the highest point of this part of the mountains, and it is barely possible that toward the main axis the species may

rise still higher. By frequent checking of the aneroid with several bench marks just established by the U. S. Geological Survey, it was possible to attain a high degree of accuracy in the determinations of altitude about Paradise.

While the distribution of the species is profoundly influenced locally by geologic origin of the rock, and probably less so by still other factors, for the sake of clearness these are at present left out of account. The two things that appear from the foregoing facts are:

1. The *constancy* of the species in question in choosing *a steep and more or less rocky surface as a habitat*, whether this be outcropping bedrock, boulder-strewn areas, or transported material distributed usually in banks and bluffs along the water courses.

2. *Its variability of aspect as governed by altitude.* While at an elevation of 3000 feet and under, which is probably near its lowest limit, it grows only in more or less protected places of north aspect, it appears to lose its aspect preference as the altitude rises to about 5000 feet, but near 6000 feet and over, it is just as definitely limited to southerly exposures as near 3000 feet and under it is confined to northerly ones.

A parallel case of higher range is that of *Quercus reticulata* HBK. In the Chiricahua Mountains this oak, at 6000 feet, was found as a leading species among the other oaks on a steep north slope in Riggs' Canyon, while from a west slope immediately adjoining it was absent. Like *Lippia wrightii*, it is not at all of general distribution in the region observed, and it was at first a surprise to find at the head of Pine Canyon 2000 feet higher in almost pure growth a dense chaparral of this oak on a very steep slope facing directly south. The two slopes are less than 10 miles apart. At the first-mentioned altitude it is also found in the bottom of deep, narrow, well-watered canyons, notably Rock Creek Canyon, and thus furnishes a second high altitude parallel, this time to the case of the following species:

At Tucson, at an elevation of 2200-3000 feet, five characteristic species that inhabit the washes, but, comparatively speaking, are with one exception almost absent away from them, are *Parkinsonia torreyana*. Wats., *Acacia greggii* A. Gray, *Prosopis juliflora* (Sw.) D. C. *Zizyphus lycioides* A. Gray and *Celtis pallida* Torr. The first-named is confined, practically without exception, to certain washes and their banks; the second likewise, except that it follows the water courses upward to finer ramifications, and occurs, as a few individuals only, on the northwest slope of Tumamoc Hill; the third is on the upland found only as small and widely separated individuals or groups of such; the fourth, usually sparingly represented here as elsewhere within the region observed, is the almost invariable companion of *Prosopis* in its typical lowland woods; the fifth occurs either on washes where considerable water is present at times, or about cliffs or extremely rocky places, usually facing northward.

As the foothills of the Tucson Mountains are reached, *Parkinsonia torreyana* at least in one place can be seen to climb the hillside along with *Parkinsonia microphylla*, *Celtis pallida* hides no longer behind rocks, but comes out more openly, and *Acacia greggii* becomes a pronounced constituent of the general shrub cover. One mile up Ventano Canyon in the Santa Catalina Mountains, at about 3500 feet altitude, is a north slope that supports *Acacia greggii*, as well as the *Prosopis* and *Zizyphus*. The latter pair may be found commonly on gravelly upland soil west of Tres Alamos, at about 4000 feet, while in another part of the San Pedro Valley, east of Fairbank, at similar elevation, *Zizyphus* was noted on upland soil, this time alone, in company with other shrubs.

Prosopis juliflora, while fringing the saccaton bottom of Babocomeri Creek, and lower down developing into a fine riparian forest, spreads over the bluffs on either side, dotting a vast plains area gently sloping away toward the distant mountains, in the low, matted form characteristic of the species in the upland habitats of

its higher range. This is but one example of a dozen that might be given to illustrate the higher distribution of this kind of desert species. *Acacia greggii*, at this same altitude of about 4500 feet, while developing to tree-like size in the water courses, was seen in places to spread all over the seemingly desiccated bluffs adjoining. Again, between Mescal and Pantano, the former at 4000, the latter at 3400 feet, is a drift area gently sloping westward, the easternmost extension of the Tucson Plains. On this are found *Acacia greggii*, *Zizphus lycioides* and the mesquite as typical constituents of the upland society.

Descending from the Rincon mountains toward Vail by way of Mountain Springs Ranch, *Acacia greggii* is again met growing generally over the open foothill country, here not over 3400 feet above the sea. With it is associated, in even greater numbers than in the Tucson mountains, *Celtis pallida*, yet there are no rock outcrops, and no washes. But most interesting of all, because so strictly confined to certain washes lower down, is the appearance of a third species, *Parkinsonia torreyana*, as a common and evenly distributed member of this upland society. Another significant fact is that its sister species, *Parkinsonia microphylla*, at lower elevations a very conspicuous and prevalent element of similar landscapes, is absent. Not until Vail is nearly reached, does it appear. Finally, approaching the Santa Rita Mountains at Helvetia, beginning with the first gentle rise where *Lippia* was seen, at probably 4000 feet, the only four shrubs that are thoroughly characteristic of the upland are again the four most typical wash species of Tucson, viz., *Parkinsonia torreyana*, *Acacia greggii*, *Prosopis* and *Zizyphus*. Again, as near Vail, *Parkinsonia microphylla* is conspicuous by its absence. Similarly, *Acacia greggi* has left behind its congener, *Acacia constricta*, although at lower altitudes the latter species is a close and abundant companion and follows the washes and gullies much further toward their head.

Lastly, where some 500 feet higher the general slope begins to merge into the foothills, the mesquite still persists, the only species of the four, while *Celtis pallida* becomes prominent and well distributed on open topography devoid of rocks, similar to that of the Rincons.

Thus we have in these five species a very decided tendency with lowering elevation to confine themselves to water courses and to certain other places offering good soil moisture conditions, and a certain degree of protection from the drouth and heat of the desert. The above facts concerning the nine species mentioned are too few to permit of generalization, but they furnish pointers for research. They appear to indicate that the factors of pre-eminent influence are the intimately associated ones of moisture and temperature, and less so, that of light. The feeling can hardly be escaped that the establishment of centers of distribution, and lines of dispersal, belongs to an exceedingly remote past and therefore these are hardly traceable. On the other hand, there is clearly evident a very high degree of adjustment between plant and habitat, in distribution no less than in structure and in form. In other words, equilibrium between flora and environment has long been established.

Tucson, Ariz., March 16, 1908.

ACROSS PAPAGUERIA.

(Continued.)

By DR. D. T. MACDOUGAL.

The opuntias with flattened stems as well as the cylindrical forms force themselves persistently on the attention of the traveler in Papagueria, and great discomfort or even serious injury may result from an unguarded encounter with these armed plants. The heavy, rigid spines on the semi-rigid joints, may penetrate deeply into the flesh, and the glochids which form short tufts at numerous places on the surface, are easily detached and quickly work into the skin

with highly unpleasant results. It is to these structures that attention is chiefly directed to get an opuntia useful for forage and salad. A dozen species, spineless, or nearly so, are known, but the breeder must get a form which does not develop the glochids beyond a rudimentary stage if the most offensive features of the armament are to be avoided.

Some of the cylindrical forms are arborescent with widely spreading branches. The joints are easily detachable so that a slight contact causes the spines to pierce the clothing or skin and a joint of the stem comes away bristling with a score of spines and some of these also pierce the flesh. The instructed use a stick or a pair of tweezers to remove the pest. Dogs, horses and cattle reared in a cactus region, learn to free themselves by a shaking motion. Attempts to remove the detached joints by the fingers are often disastrous.

The ease with which the joints are detached, the facility with which they become attached to animals and the rapidity with which these segments root and form new plants when dropped, make this one of the most important methods of reproduction. This is true especially of *Opuntia mamillata* and *O. fulgida*.

These two forms were formerly thought to be included in a single species, but on all of the expeditions from the Desert Laboratory, they have been found easily distinguishable. They offer a marked example of closely allied forms living in the most intimate proximity.

The acid fruits are not set free until they are three years old in some instances. After the pulp decays, the hard seeds lie on the ground inactive for months or even years, meantime being subject to the action of numerous rodents which gnaw through the hard outer coat to get at the embryo. Both species are known as "cholla," a name loosely used, and sometimes applied to any cylindrical opuntia, although it strictly belongs to a species native to Baja California (*Opuntia cholla*).

A number of rodents fortify their burrows with joints of the cholla which are dragged into such position around the entrances as to allow a crooked passage for the occupants, but which would discourage the marauding coyote, cat or fox.

The spines and glochids of the cacti do undoubtedly lessen the ravages of grazing animals to some extent, but no ground is afforded for the conclusion that the armature is a direct and purposeful response to the injuries inflicted by animals. The structures in question seem to have been induced by aridity, and in a dozen species the evolutionary



FIG. 1—Chollas (*Opuntia fulgida* and *O. mamillata*) in the vicinity of Tucson.

development has been carried still farther and the spines are reduced to the merest rudiments. Singularly enough, the two poorly armed species, occurring in the vicinity of Tucson, are not seriously molested by animals. It is also to be noted that while the cacti seem to be especially suited for arid conditions, yet many species occur in moist tropical forests.

Two massive forms of melon cacti or bisnagas, (*Echinocactus wislizenii* and *E. emoryi*) were encountered by our

expedition at elevations above a thousand feet in Sonora and Arizona, while a third, with a number of smaller heads in a cluster, was seen nearer the Gulf of California. The larger species often measure over five feet in height with a diameter of more than two feet at the base, containing as much as 200 lbs. of water. This sap is only slightly charged with substances ordinarily in solution in the plant cell, and an Indian runner, striving to make a swift journey in Papagueria, need not carry water with him, but may resourcefully shape his way to meet with these "bisnagas" from which a grateful supply of satisfying liquid can be quickly obtained. Some travellers speak slightly of the juice as a drink, and magnify the difficulty of its extraction. It has, however, proved useful on many expeditions, and if the thirsty traveler is so fortunate as to be armed with an ax or a large knife, he may secure a quart of liquid within seven to ten minutes. Lacking these, he must burn away the huge spines and then crush the top and pulp with a stone before the juice can be squeezed with fingers into a centrally made cavity, a method which may need twice as much time, but which might avoid serious consequences from thirst in a region in which a man at work uses as much as sixteen pints of water daily.

Not all melon cacti can be expected to yield their store of water so readily, however. *Echinocactus grande* attains the height of seven or eight feet, and a thickness of a yard in the desert of Tehuacan in southern Mexico. The firm pulp is heavily loaded with lime, so that when chewed it is unpleasantly gritty; the juice is not obtainable by the methods used with the Sonoran species.

The route of the expedition lay almost due west from Tucson for a distance of over a hundred miles, until the northern end of the Ajo mountains was rounded and then Sonoyta was made on the river of the same name, across the international boundary. Here during the remainder of the trip, many interesting interpretations of place names derived from plants were met. "Ajo" itself was found to mean



FIG. 2—Papago Indian drinking juice of bisnaga (*Echinocactus wislizenii*).

garlic, and the mountains, peaks, and valley which bear this name, were so designated because of the abundance of the plant in their vicinity. When our Mexican guide pointed out the so-called garlic, however, it proved to be *Hesperocallis undulatus*, a liliaceous plant with a bulb eight to sixteen inches below the surface, from which the flower stalk and the crinkled leaves are sent up during February and March. The plant is found from northern Arizona to far south in Sonora.

The general structure of the oasis of Sonoyta is fairly representative of such formations in American deserts, and its principal features merit description. A great ovoid plain forty or fifty miles across, lies mostly south of the international boundary with its narrower and lower portion to the westward. The plain, once a great basin-like valley, is now filled with detritus from the encircling mountains to a depth of a few hundred feet. The greater part of the precipitation here and on the slopes of the neighboring mountains, sinks down in this broken material, forming running streams on the surface only during seasons of great precipitation. The water percolating through the detrital mass gradually makes its way toward the lowest part of the original valley, this being facilitated perhaps by layers of clayey material or hard-pan impervious to water, with the result that in following this horizontal layer it is brought to the surface by various converging lines of drainage at the lowest part of the gravel-filled valley, this occurring within a mile of the international boundary in the present instance. The stream formed, flows along over the margin of the clayey layer, being exposed to enormous evaporation, and furnishing a supply which may be led out in conduits for irrigation purposes. Lower down it encounters the sand or gravel beneath the clay and again it sinks into the ground. In the brief seasons of flood, the stream may run far down before it is swallowed by the porous sands, and as aridity increases, the end of the water recedes far up stream. It is this short reach of living stream that forms the heart of the oasis, nourish-

ing as it does a vegetation widely different from that of the surrounding desert and affording conditions for the cultivation of food-plants for the human animal. The oasis of Sonoyta has doubtless been the site of a cluster of habitations since the beginning of agriculture, and it has been known to



FIG. 3—Great bisnaga (*Echinocactus grande*) of southern Mexico.

the Papagoes for a thousand years by this name, meaning the place where corn (sonot) will grow. Very naturally the upper part of the oasis has the surest supply of water and the steady population of about 150 people have shifted along the sides of this in accordance with the changes in the stream and alterations in the irrigation systems. The

lower, uncertain part of the stream with its precarious conditions has been followed by hunter's camps and sporadic ventures with small flocks, the oft-recurring seasons of extreme drought discouraging any more serious operations. Forage, corn, wheat, melons, figs, grapes, and dates are grown and with the exception of some introductions following the first visit of Father Kino in 1699, the mode of life of the Mexican and Indian population has changed but little in two centuries.

The heavy growth of mesquite, (*Prosopis*), arrow-weed (*Pluchea*), batamote (*Baccharis*), palo verde and bigote (*Parkinsonia microphylla* and *P. torreyana*) of the oasis are in sharp contrast with the desert vegetation comprising the pitahaya (*Pilocereus thurberi* and *P. sargentii*) and sahuaro, nopal and tuna, ocotillo and sangre de drago a few feet away, the margin of the oasis being as well defined in many places as the edge of a carpet.

The length of the oasis was traversed in easy stages by our expedition, a final camp being made at the end of the stream of running water at Agua Dulce, below which the broad channel is coated white with alkaline salts bearing a characteristic vegetation inclusive of the widespread salt-grass (*Distichlis spicata*). The further route now carried us westward across a desert of the most pronounced character to Monument 180 on the international boundary and southward to Papago Tanks on the western slopes of the Pinacate mountains. The water supply here and in this region is to be found in a few small kettle-holes in the granite lying in the streamways and filled by the rains. Most are shallow and uncertain, but two beside the one mentioned being reliable so far as the information of our scout could be depended upon. The topographic features presented by this volcanic region afforded conditions for some unusual groupings and occurrences of plants. Over 250 cinder cones and craters were counted and a tenth of this number were visited. The loose but steep slopes were thickly covered with

the Bigelow's opuntia, so thickly in fact, that in making the ascent, great care was necessary to escape sliding into them by reason of the insecure footing. The sahuaro and a number of other plants descended into the huge well-like craters occupying the floor at a level but a few feet above the sea. Low stretches in the valleys were occupied by a rank growth of the galleta grass, affording a coarse food for our horses. *Opuntia kunzei*, unknown and new at the time, was encountered in abundance, torote prieto and torote blanco, small shrubs (*Burseras*) occupied the hillsides, while *Covillea* formed a mosaic over the whole region.

Toward the Gulf was to be encountered a band of sand dunes sixty and eighty feet in height with a coastal belt of salt-loving and halophytic species beyond a broad zone of galleta grass.

A general view of the entire region shows that a number of species extend over its entire breadth from elevations of 3000 and 4000 feet in southeastern Arizona to the dunes near the shore of the Gulf, a distance of 200 miles. Among these are to be included *Cereus giganteus*, *Covillea tridentata*, *Encelia farinosa*, *Prosopis*, *Fouquieria*, *Parkinsonia*, all of which are essentially desert species, showing marked xerophytic structures. The highly localized distribution of the greater number of forms, makes it extremely difficult to make an analysis of their inter-relations and limits. The vegetation is essentially subtropical and a few of the forms mentioned extend far to the southward in this coastal desert. A large number of annuals, active only during the rainy seasons, are included.

STOMATA AS REGULATORS OF TRANSPIRATION.

By FRANCIS E. LLOYD.

The history of plant anatomy is not older than the knowledge that, leading from within the plant to the outside are numerous openings whose appearance is now a matter of elementary experience to every one more than superficially

interested in the plants. These openings soon became known by the name of "stomata" or as the less euphonious anglicised form has it, "stomates," since they impress one at first sight as small mouths. That they are analogous to the mouth in the animal is a notion to be commonly met with in the elementary text-books, justified however, only on slender grounds, and too often leading to a distorted conception of the purpose of the stoma in the economy of the plant. This is, however, not the only more or less inadequate or indeed misleading idea about this organ presented in the text-books, as it will be the object of this account, in part, to show.

It has happened that the study of the stoma, historically considered, has been prosecuted in two general directions, in that of structure and mechanical operation, and in that of physiology. This does not mean that botanists who have studied one of these phases of the subject have always done so to the exclusion of the other, but it would contribute no important or essential detail to the discussion to go into the details necessary to the exact presentation of the history of the study. On the anatomical side, the stomata of a multitude of plants have been studied merely as details necessary to a full knowledge of the structure of plants; they have been studied comparatively with the hope of resolving the manifold forms into phylogenetic types; these manifold forms have been examined with the purpose of showing that this type is more or that less effective with reference to a particular mechanical operation, especially as controls of the diffusion of water-vapor out of the plant commonly known as transpiration; and, regarding them as mechanisms pure and simple, their peculiar mode of operation, and the anatomical details contributory to it, have been the subject of the most masterly examination. The amount of detailed knowledge thus gained is very great, and a mere citation of the papers containing it would be quite imposing. Among these many, the essay of Schwendener will always stand as the master-

piece, and certain of his drawings are now to be found in almost every botanical text-book. He showed especially how the stoma works, as a machine, and laying aside the physiological part of his work in this field, the impetus which he gave to the study of the stoma is due chiefly to this. In our own country, Copeland studied a considerable number of kinds of stomata, extending our knowledge of their manner of working.

As to the way in which the stoma serves the plant, every possible view has been held. It was early thought that it was their function to allow the entrance of light into the interior of the leaf. This indeed they do, but now we know that the cuticle does so, and that, were the stomata all plugged with an opaque substance, there would be but the merest amount of interference to the passage of light. That these organs allow the escape of water vapor, and the entrance and exit of gases are facts. But whether the primary object is to allow the escape of water, or to establish a sufficiently intimate relation between the interior of the plant and the surrounding atmosphere is still debated, the weight of opinion appearing to be, at present, on the side of those who contend that the plant is trying to save its water-supply, and at the same time to give out and take in the gases involved in its protoplasmic activity. But the view that the stomata are the "regulators of transpiration" is not without its supporters and the fact that they open and close is a fact which seems to corroborate this idea. It has been supposed that this opening and closing is closely correlated with the amount of water vapor which escapes, and that when the amount of vapor escaping is too great, thus tending toward undue loss and consequent wilting, the stomata close, with the result that the danger is averted, to an extent sufficient at least to off-set danger which is not too great. It was the writer's task to begin in 1904 a study of stomata with the view of testing in particular the idea that transpiration is regulated by the opening and closing of

the stomata. With the substantial help of the Botanical Society of America and of the Carnegie Institution of Washington, it was possible to carry on this study in the desert near Tucson, Ariz., at the Desert Botanical Laboratory. The results of the work, which extended over the major portion of three years have been published *in extenso* as Publication No. 82, of the Carnegie Institution of Washington. A brief account of certain of these results will here be given.

If it is true that stomata regulate transpiration, we should expect to find that the opening of the stoma would result in an increase in the amount of transpiration; and contrariwise, a closure, apart from complete shutting which scarcely occurs, would be accompanied by a decrease in transpiration. At a given degree of opening we should find a constant amount of vapor loss. At maximum opening, a constant maximum of transpiration should occur. It is only if these be facts that anything like regulation may be recognized to occur. To find the truth, it is necessary to be able to determine the rate of transpiration and the size of the stomatal openings independently at the same instant of time. It is obvious that we may neither judge the rate of transpiration from the size of the openings, nor the size of the openings from the rate of transpiration. How to do this was the difficult task, but with a sufficiently small error, this was done in the following manner:

It was found that the stomata of certain, and probably many, plants may be fixed in the form in which they are found in life by tearing off the epidermis and plunging it into absolute alcohol. The distortion of the stomata caused by the tearing is only temporary, the guard cells recovering their form just as a rubber ball does when it has been released from pressure. The alcohol extracts the water from the cell-walls, thus rendering them rigid, and this it does so rapidly that they do not have a chance to lose the water contained within the protoplast while the walls are still pliable, a process which would result in closure.

Epidermis treated in this way may be preserved in absolute alcohol indefinitely, or it may be stained in a solution of congo-red in absolute alcohol, cleared in clove oil and mounted in balsam. If, however, water is allowed to get access to the stomata at any time, the cell walls will become soft and the guard cells will act as if plasmolysed. The stomata will then close and the preparation be valueless for the purpose it was intended.

With this method of observing the stomata available, enabling one to measure and count under the microscope as many as necessary at one's leisure, it remained to get hold of a method of measuring rapidly and with sufficient accuracy the rate of transpiration from the plant, the stomata of which were to be examined by the above outlined method. Such a method was had by a modification of the glass tube potometer, in which was used an ordinary glass tube of, say 5 mm. bore, or better a chemical burette to which was connected, by a piece of rubber tubing, a branch of the plant studied, which was the ocotillo (*Fouquieria splendens*). Careful manipulation made it possible to observe the rate of transpiration after the first hour or two, for a period of 24 hours or, in some cases, for two or three days. A whole experiment when set up and running consists simply of the piece of the plant, a glass tube placed parallel to it and tied, and the lower ends of both properly connected with a short piece of rubber tubing, the whole being suspended where desired. It will be seen that such a simple device makes it possible to have several exactly similar experiments going on at the same time, and, in such case, it will be seen too, that each will act as a control on the others. If one of them acts very much differently from the rest, it may be discarded. Uniformity of operation in a number of experiments is a good guarantee that they are all working well and normally. To be sure several objections may be raised to the use of the potometer as a physiological instrument, but in this connection it can be made to

register the rate at which water is leaving the leaves as vapor. The proof of the matter can be had by simply weighing the whole system at different times, when the difference in weight should equal the difference in the amount of water which has disappeared from the tube. In using the two methods in conjunction, one takes a piece of the plant to be studied with a sufficient amount of foliage so that the removal of a few leaves will introduce a negligible error, arranges it in a "vertical tube potometer," and, by changing arrange is in a "vertical tube potometer," and, by changing the surrounding conditions, as from darkness to full sunlight, one causes changes in the rates of transpiration, and, by removing leaves and preserving the stomata, one is able to obtain the data sought. We may now pass on to examine the nature of the evidence thus discovered.

By arranging a series of experiments to be allowed to run for a period of something over twenty-four hours, the course of transpiration for such a period may be obtained; and by taking specimens of the stomata at given hours we may trace the course of normal stomatal movement for the day also. The degree of correlation between the two will at once be displayed upon the examination of the data, or better still by plotting these in the form of curves. Data thus obtained show that, after the maximum degree of stomatal opening has been obtained, the rate of transpiration continues to become more rapid. During the period in which the maximum opening of the stomata is retained, the rate may again fall, and during the latter part of the day, when the stomata are closing, the movement may continue steadily, while positive fluctuations in the transpiration rate occur. The conclusion must therefore be reached that the movements of the stomata between the extremes appear to bear little relation to the fluctuations which may occur in the rate of transpiration. Such changes are, however, not very marked during a short period of time under normal circumstances. By placing the experiment under conditions of marked and

rapid change much more marked quantitative responses may be induced. If a plant is removed from total darkness and placed in bright illumination, there follows a marked increase in the rate of transpiration. The inverse change is followed by an inverse response. Is this increase or decrease due to a correlated change in the size of the stomatal openings? If so we should find that the maximum transpiration rate is reached simultaneously with the maximum stomatal opening. The fact appears, however, to be far different. Without giving tedious figures, it may be said briefly that with little or no movement in the stomata, and therefore with little change in the size of their openings, wide fluctuations in the rate of transpiration may and do occur, and so far as experience shows, the maximum possible rate of transpiration, judging from the size and number of the stomata, has not been observed. Brown and Escombe found, for example, in the sunflower, that the observed maximum rate of transpiration was only one-sixth the possible rate supposing the full diffusive capacity of the stomata to occur. It appears further to be true that the loss of water from the plant through the stomata may be so great that wilting may ensue and progress for a not inconsiderable period, before the stomata begin to close. Thus the effectiveness of these organs as regulators of water loss is so slight that even when the danger is great, it is met only in a very tardy and insufficient way. This is further shown to be the case by the observation that the removal of a plant from a damp atmosphere to a dry one does not lead to the closure of the stomata unless the change is one sufficient to cause wilting, when the stomata close the movement of closing being caused by the loss of water from the leaf as a whole, and not as a check becoming effective before wilting sets in, a view held by Francis Darwin.

By way of summarizing, then, we may conclude that, for the present, and in the light of the facts obtained by the methods used, the evidence now in hand does not support

the view that stomata are regulators of transpiration, in the the plants studied. These are not markedly desert types as far as the stomata are concerned, and the amount of water vapor which may escape through one type of stoma per unit of time may be greater or less than that which may escape through another type. The structure of the stoma, as that of other organs, may indeed explain why some plants are able to get along in the desert, and others not. Stomata of a given form may act as a dampener on transpiration, just as, using an analogy, the mute in a cornet reduces the amount of sound which emerges from the instrument. But the mute does not regulate the sound, causing now more and now less in successive intervals of time. In this sense, also, stomata can not be said to regulate the flow of water-vapor from the leaf. Nor do they "anticipate" wilting, the closure of stomata during this process being as much a result of the wilting as the flaccidity of the other cells of the leaf. We must therefore give up for the present the long cherished notion that stomata are delicate valves opening and closing rapidly to modify the rate of transpiration as the needs of the plant indicate.

Mazapil, Zac., Mexico.

EXTRA-FLORAL NECTARIES IN THE CACTI.

By FRANCIS E. LLOYD.

The cacti are to be numbered among the plants which possess nectaries other than those which are found in the flower, and it appears that many more cacti than would be expected are characterized by their presence. I have often been surprised by observing very considerable numbers of ants crowding the younger branches of certain of the *Cylindropuntia*, even when the plants were not in flower, and this, I believe, is to be explained by the secretion of nectar which is always sought for by ants, and some other insects, when extra-floral nectaries occur.

My attention was first drawn to the extra-floral secretion of nectar in these plants in the case of a *Mamillaria* (Cacti of N. Zac., Mex., No. 31*) with large mamillæ. The upper surface of the mamilla is grooved broadly, the groove being lined with a thick felt of hairs. In this groove occur the nectar glands, the largest of which lies near the pulvinus, and is dull orange in color. The exposed surface is slightly convex. When the plant is thoroughly washed to remove all the nectar from the exterior of the surface, and placed in the sunlight, the whole becomes thoroughly dried, except, probably, the felt of hair which is found not only on the grooves but about the apex of the plant as well. In about three hours the extrusion of a perfectly limpid fluid from the center of each gland becomes evident, and in the course of a day every active gland will have a good sized, clear drop of nectar standing up from the centers of the glands. It appears that the presence of water in contact with the outer surface of the glands is not necessary, though it was suspected that moisture in the felt of hairs adjacent to the glands might help to start the secretion, or rather the extrusion. In the plant studied almost all the mamillæ secreted nectar, the largest drops occurring on the younger mamillæ. The nectar quickly becomes very syrupy, and often the sugar will become granular so that the nectar may be broken away from the gland. Such an amount of nectar is produced that it often runs into the felt and renders the whole groove-covering sticky and matted with the syrup.

Similar glands occur also in a species of *Echinocactus* (Cacti of N. Zac., Mex., No. 2) in which their distribution and appearance is similar to those in the species of *Mamillaria* just discussed. The rate of secretion appears, however, to be more rapid than in the latter, though it is confined to the

*The plants here referred to are designated by my collection numbers, the specimens having been deposited in the U. S. National Herbarium.

upper mamillæ. The species is popularly known as "vaca" (Cow-cactus) and is eaten raw, it serving to allay the thirst.

In the species of *Echinocactus* (*E. pringlei* Rose, Cac. N. Zac., No. 13) known here as "biznaga colorada" nectar glands occur just above the pulvini as three conical protuberances of yellow or orange color, about 5 mm. long, and arranged in an obtuse triangle with the apex directed upward. The extruding nectar appears first as a minute droplet on the apex of the cone-shaped gland, and in the field the glands are often found coated with a crystalline mass derived from the evaporated fluid.

Two other, as yet undetermined, species of *Echinocactus* (Nos. 10 and 33) have also been found to possess nectaries. In the former species, No. 10, they have the same form as in *Echinocactus pringlei* Rose, but are more numerous, arising in acropetal order, new ones being formed as the older ones die. No. 33 has apparently only one nectar gland, just above the pulvinus, and expanded transversely as regards the ridge.

In *Opuntia imbricata*, No. 21, the nectar glands are two in number on each pulvinus, so far as I have been able to determine them up to the present moment. They are placed just within the first pair of lateral spines formed, and are readily seen in the young branches as small pale green areas unclothed with hairs such as render the pulvinus apparent. The amount of nectar formed in this species from any one gland is not very great, but apparently there is enough to attract many ants.

In view of the number of species in which nectar glands have been found by me, it seems probable that these structures are widely distributed in the family.

Mazapil, Zac., Mex.

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THE FLOWERING STALK OF THE CENTURY PLANT.

By DR. W. B. MACCALLUM.

During the past spring an unusually large number of century plants, *Agave Americana*, blossomed in the vicinity of Tucson, and a record was obtained of the rate and amount of growth of the remarkable flower shoot of two of these plants. The individuals selected for observation grew in the botanical garden of the University. One was measured daily at the same hour as nearly as possible to obtain a record of the daily increment, and the other was marked into zones and measured occasionally, to determine the region of most active elongation. The former plant was a rather large specimen (Fig. 1:) with a striking rosette of the characteristic thick, succulent, erect leaves whose tips reached to a height of 8 ft. 5 in. above the ground. As the contents of these leaves were gradually withdrawn to the stalk, there was a marked decrease in volume, and also turgidity, accompanied by a loss of mechanical rigidity, until finally they were quite flaccid and drooped over to the ground. It would seem that the great rigidity of these leaves lies in their high turgidity rather than in any mechanical tissue they possess. Ultimately there is a complete exhaustion of all contents except the fibrous and woody parts, the leaves at last becoming quite dry and brittle. A leaf cut off before flowering weighed 2910 grams. After flowering a similar leaf

which had remained attached to the plant, but was now hard and dry weighed 262 grams, a loss of 91 per cent in weight. The bulk of this was water, but no doubt there was considerable weight of other materials. After the stalk starts to elongate, probably the only source of food and in many cases water too, is that stored in the leaves. The total amount withdrawn from the leaves in a short time must be very considerable, for in two months the stalk reached a height of over 33 ft. with a spread of branches approximately 7 feet wide. The diameter of the stem 5 ft. 6 in. from the ground is 10 in. There are 29 branches, having an average of 270 flowers each, a total of 7250 flowers. These are large, averaging $3\frac{1}{2}$ in. in length just before opening, and weighing four to an ounce, making a total weight of flowers alone of about 114 lbs. An apparently average branch was removed and found to have a weight of 6 lbs. so that the aggregate weight of flowers and branches amounts 174 lbs. An estimate of the weight of the stem was obtained in this way; a somewhat smaller flowering shoot had been blown down by the wind, but too much scattered to secure the total weight. A piece of the stalk of definite dimensions was weighed and the mass obtained. The mass was .40 cubic ft. and the weight 16 lbs. From the dimensions of the stem of the plant in question, the mass is 8 cubic feet, and if its relative weight is the same as the other, it would be 320 lbs., making the total weight of the flowering shoot to be 494 lbs. Of course, this is only approximate, but it is probably pretty close to the real weight.

The food material for this growth is as mentioned, drawn entirely from that stored in the leaves for they soon begin to wilt and it is not likely they do any significant amount of synthetic work after that. As to the source of water, the following observations may be of interest. On May 7th, the soil in which the larger agave was growing was given



Fig. 1. *Agave Americana*. Distance from ground to top of rosette 8 ft. 5 in., and to apex of shoot 15 ft. 1 in. An elongation of 9½ inches occurred on this day, April 14, 1908.

a thorough irrigation. Up to this time there had been very little spring rain and the shallow soil was parched dry. The accompanying table shows no more increase of growth on the days following than the usual daily variations would account for. The other plant was irrigated on April 4th. From April 8th to 14th, the elongation of the shoot was 3 feet, 3 in. An average of $6\frac{1}{2}$ in daily. From April 14th to April 18th, the increment was 25 in., or a daily average of $6\frac{1}{4}$ in. It should be noted that this was while the leaves were still turgid and probably the growing portion of the shoot was supplied with sufficient water for the maximum growth. Later as the leaves were wilting, and the reserve supply diminished, a different result might be obtained, though it may be added that it is a matter of common observation in this region, for agaves to bloom and fruit normally in soil so dry that the stored water is the only possible available supply.

After the stalk had ceased elongation, and when many of the leaves were only partially wilted, (others quite dried up) the dry soil was again irrigated. No appreciable growth (in length) of the stalk resulted, and no increase in the turgidity of the leaves could be noticed.

Regarding the age of these plants, the larger one was set out as a two year old rosette in 1894, the other a few years later, but just when is not known.

Measurements were started on April 8th, 1908, and continued daily until June 2nd, when growth had practically ceased. Owing to the difficulties in measuring, an error of at least half an inch was unavoidable. This may effect the record for any one day, but the average rate for a series of days would not be prejudiced.

The following table shows the daily growth from April 8th to June 2nd. After that the growth was too slow for measurement, being 3 in. in 13 days. After June 15th, no



Fig. 2. *Agave Americana* shown in Fig. 1, in full bloom, July 1, 1908. Distance from ground to apex of inflorescence, 33 ft. 9 in.

further elongation occurred. As will be seen, about April 20th there was a falling off in the rate of elongation. The reason may be in the fact that shortly after this time, the later branches became evident and though their elongation at first was quite slow, yet no doubt a good deal of energy was utilized in their formation.

Date	Height	Growth	Date	Height	Growth
April 8	11' 9"	4	May 7	24' 3"	1
" 10	12 8	1	" 8	24 8	5
" 11	13 3½	7½	" 9	25 2	6
" 12	14 0	8½	" 10	25 7	5
" 13	14 9½	9½	" 11	26 0	5
" 14	15 1½	4	" 12	26 5	5
" 15	15 8	6½	" 13	26 9	4
" 16	16 4½	8½	" 14	27 1	1
" 17	16 9½	5	" 15	27 8	7
" 18	17 3½	6	" 16	28 1½	5½
" 19	17 8½	5	" 17	28 6½	5
" 20	18 1½	5	" 18	29 0	5½
" 21	18 6	4½	" 19	29 5	5
" 22	18 10½	4½	" 20	29 10	5
" 23	19 3	4½	" 21	30 2	4
" 24	19 6	3	" 22	30 7	4
" 25	20 0	6	" 23	31 0	5
" 26	20 5	5	" 24	31 4½	4½
" 27	20 10	5	" 25	31 9	1½
" 28	21 2	4	" 26	32 1	4
" 29	21 6½	4½	" 27	32 4	3
" 30	21 11	4½	" 28	32 7	3
May 1	22 3½	4½	" 29	32 9	2
" 2	22 8	4½	" 30	32 11½	2½
" 3	23 0	4	" 31	33 2	2½
" 4	23 4	4	June 1	33 4½	2½
" 5	23 7	3	" 2	33 6	1½
" 6	23 11	4	" 15	33 9	3

The greatest elongation in any day was 9½ in.; the greatest daily average for a week was for the week ending April 16th, and was 7 5-14 in. The mean for the total period observed was approximately 5 in. per day.

The stalk of the other plant mentioned was marked off into zones to determine the region of elongation. These zones were 6 in. broad, starting at the base, the final one at the apex being only 4 in. The following table shows the relative growth, the numbers being from the apex downwards:

It appears from this that the region of most active elongation is that lying a short distance, perhaps about 12 in. below the apex.

Zone	April 8th	April 14th	July 5th
1	4 in.	8½ in.	37 in.
2	6 "	17 "	85 "
3	6 "	13½ "	57 "
4	6 "	9 "	14 "
5	6 "	7½ "	9½ "
6	6 "	6½ "	7½ "
7	6 "	6½ "	6½ "
8	6 "	6¼ "	6½ "
9	6 "	6 "	6 1-3 "
10	6 "	6¼ "	6½ "
11	6 "	6 "	6¾ "
12	6 "	6 "	6 1-3 "
13	6 "	6 "	6¼ "
14	6 "	6 "	6 1-3 "
15			6 "
16			

DR. BAUR ON VARIEGATION.

By DR. GEORGE H. SHULL.

In the April number of the *PLANT WORLD* in a very suggestive paper on the nature of certain bud variations Dr. East says that, "it is probable that some at least of the cases of variegation will prove to be pathological." Through the splendid work of Dr. Erwin Baur* so much is already known regarding the nature of variegation that it seems appropriate in this connection to present a brief resumé of the results of his studies.

It is found that there are two fundamentally different kinds of variegation whose external appearance is very similar, but whose methods of transmission are totally unlike. One type which Dr. Baur calls "infecious chlorosis" is a pathological condition and it is to cases of this kind that he has given most attention. This kind of variegation is not

Baur, E., Zur Aetiologie der infektiösen Panacierung. Ber. Deutsch. Bot. Gesell. 22:453-460, 1904.

Über die infektiöse Chlorose der Malvaceen. Sitzber. Kgl. Preuss. Akad. Wiss. Jan. 11, 1906, p. 11-29.

Weitere Mittheilungen über die infektiöse Chlorose der Malvaceen und ueber einige analoge Erscheinungen bei Ligustrum und Laburnum. Ber. Deutsch. Bot. Gesells. 24:416-428, 1906.

Über infektiöse Chlorosen bei Ligustrum Laburnum, Fraxinus, Sorbus, Ptelea. Ber. Deutsch. Bot. Gesells. 25:410-413, 1907.

Untersuchungen ueber die Erbliehkeitsverhaeltnisse einer nur in Bastardform lebensfaehigen Sippe von *Antirrhinum majus*. Ber. Deutsch. Bot. Gesells. 25:442-454, 1907.

transmitted at all through the seeds. The other type of variegation is a normal inherited quality transmitted to the offspring just as any other normal quality might be. The latter type of variegation is not at all infectious.

It has been known to gardeners for 200 years that the grafting of a variegated cion into a green-leaved stock may make the latter variegated through "graft infection," and *vice versa*, that a green cion set into a variegated stock is apt to become variegated. The most familiar cases of this kind are found in the Malvaceæ, in which a considerable number of variegated varieties have now been formed through the infection of different species by means of grafting. All of these varieties among the cultivated Malvaceæ are traceable to a single variegated specimen of *Abutilon striotum* Dicks., which was introduced into Europe from the West Indies by James Veitch & Son in 1868 and distributed under the name *Abutilon Thompsoni*.

All efforts to produce an infection by any means other than grafting have thus far proved futile and it seems evident therefore that the infection is not due to an independent organism. Dr. Baur concludes that the infecting substance is a toxin produced by the diseased cells. The production of this toxin is in large measure dependent upon sunlight. Specimens growing in the shade are much less variegated than those growing in bright light. The disease may be completely cured by removing all variegated leaves and setting the plants for some time in diffused light. When again brought into bright light no more variegated leaves will be produced. If a single variegated leaf is left on the plant, however, or if a single variegated leaf is grafted into it, the whole plant will be very soon reinfected upon removal to strong light. The cure of the plant by the shade treatment is absolute with respect to all the new growth, but if by cutting back or other means a bud is caused to develop which occupied the axil of a variegated

leaf this bud will produce a variegated branch and from this the whole plant will be again infected.

Different species of the Malvaceæ differ widely in their susceptibility to the disease. Thus, *Lavatera arborea* L. is entirely immune, *Kitaibelia vitifolia* Willd. shows much individual variability, some specimens being immune, while others are susceptible, and other species, such as *Abutilon striatum* Dicks., *A. Sellowianum* Reg., *A. Indicum* (L.) Don., etc., are uniformly susceptible.

Infection can only take place in relatively young tissues and the length of time required for infection is very different in the different species and under different conditions, but at least some days are required, thus indicating that the toxin is not carried by the transpiration stream. The same might be inferred from the complete failure to secure an aqueous extract which will produce infection. Girdling experiments with *Abutilon Avicennae* Gaertn. show that the toxin must be carried by the bark as no infection takes place on any part of the plant separated by a girdle from the variegated region of the plant, whether the latter is above or below the girdle.

The nature of immunity from the disease as manifested by certain species has been investigated also. It is found that when a cion of the immune *Abutilon arboreum* is grafted upon *A. Thompsoni*, and later a cion of *A. Indicum* is set into the *A. arboreum* graft, the *A. Indicum* becomes infected. This shows the toxin passes into and through the stems of the immune *A. arboreum* and that the latter is simply indifferent to it. However, the toxin which has entered into the immune branch is not capable of producing infection when this branch is severed from the variegated stock and grafted into another susceptible stock. Another case of immunity is interesting because it involved the origination of a new immune race in an otherwise susceptible species. Several green branches were found upon a variegated speci-

men of *Abutilon striatum* Dicks. (i. e. *A. Thompsoni* hort.). These were grafted into normal stocks of *A. striatum*, and the plants so produced proved to be immune, though all ordinary *A. striatum* plants are susceptible.

In case of the immune *Lavatera arborea* L. there is no transmission of the toxin through the immune tissues and any susceptible cion set directly into *Lavatera* wood remains green regardless of the contact of this *Lavatera*-stock with diseased tissues at some other point.

In the first of the cited papers Baur suggests that the "mosaic disease" of tobacco is of the same nature as the infectious chlorosis of the Malvaceæ. There is this difference, however, that the tobaccos may be infected by means of extracts, while the toxin of the variegated mallows seems to be incapable of existing outside of the living cells. This is not considered a difference in kind between these two toxins, however, but only in degree.

Variegation of precisely similar nature to that of the Malvaceæ is demonstrated in *Ligustrum vulgare*, *Laburnum vulgare*, *Fraxinus pubescens*, *Sorbus Aucuparia* and *Ptelea trifoliata*, and doubtless many other species will be found to be subject to some form of infectious chlorosis.

Not so much has been done yet in the investigation of the inheritable type of variegation, but it seems that many cases in which variegation forms a rather definite pattern, as for instance when it affects only the margins of the leaves, this character is hereditary.

The variegation of *Antirrhinum majus* is the only case fully studied. This presents one of the interesting cases of Mendelian inheritance on record. The green specimens are homozygous and breed true when interbred, producing no variegated offspring. When two variegated plants are crossed together the offspring present the unexpected ratio, 2 variegated: 1 green. To explain this ratio, 2:1, the as-

sumption is made that the union of two variegating allelomorphs does not form a successful zygote, and this converts the typical ratio 1DD:2DR:1RR to 2DR:1RR. This would mean that all the variegated plants are heterozygotes. To test this assumption a number of crosses were made between variegated and green individuals and in all such cases the offspring were variegated and green in the ratio 1:1 as the hypothesis would require.

It appears that *Pelargonium zonale* presents a somewhat similar situation, though this has not yet been sufficiently demonstrated. In this case the DD group is not wholly absent but is represented by completely white individuals which must succumb at an early stage of development owing to their inability to manufacture sufficient carbo-hydrate food.

THE EXPERIMENTAL MORPHOLOGY OF PLANTS.

The region where plant physiology and plant morphology overlap is considered by the comparatively new branch of botanical science called experimental morphology. It is the aim of this subdivision of botany to understand, on the one hand, what are the controlling forces involved in the development of the different plant structures, and, on the other, within what limits it is possible for these structures to vary. One aspect of the problem is physiological, lying in the broader province of irritability, and the other is morphological, lying in the province of variability. The two sides of the series of questions here involved must, of course, be developed hand in hand.

The main results so far obtained in this fascinating field of study have just been brought together by Prof. Goebel, of Munich, in an "Introduction to the experimental morphology of plants."¹ The publication of this work, which is as elementary as is compatible with the nature of the subject.

should greatly accelerate work along these lines. Besides serving as an introductory text book of convenient size and completeness for the student who has not previously worked in this subject, it will surely have a marked effect toward putting an end to much of the unhappy vagueness and obscurity of thought which has fallen to the lot of experimental morphology, as to that of all newly developed branches of science.

The author disavows all claim to completeness in his treatment of the subject and its literature. The book is to be considered as an introduction rather than as a handbook. Little attention is given to the direct influence of light, gravitation et cetera, which have been treated so fully in Pfeffer's Physiology and in Goebel's own Organography. Also, the main considerations are here with the higher plants, such as are found in gardens and plant houses and are thus of comparatively easy access. In a very large measure the cases described are from the author's own experiments, so that the reader must feel that these chapters take him into the author's plant houses and garden, not merely into his library. Most of the numerous figures, which really illustrate the text, are also original. The theoretical considerations are confessedly of a simplicity which will prove disappointing to those who have already worked with these problems, but my judgment in this regard is that these simple hypotheses have not only the virtue of being admirably suited to the needs of the beginner, but also the added one of being logically safe as far as they go. They leave the reader free to advance farther as his facts and logic will allow.

In considering the influence of external conditions upon the form of the plant, Goebel points out that these conditions must always be active through internal changes. The simplest method of thinking of these internal conditions is to view them as nutritive phenomena, and throughout the

1. Goebel, K., *Einführung in die experimentelle Morphologie der Pflanzen*, pp. VIII + 260, figs. 135, Leipzig and Berlin, B. G. Teubner, 1908.

book the theoretical treatment deals mainly with nutrition. The length of time and the number and nature of the steps involved in the process of preparation for fruiting are thus related to the amount and character of the various organic and inorganic foodstuffs present in the plant, and it is suggested that the relation of organic to inorganic substances may often control the activities of the latter. In the case of a Cocos seedling which developed an inflorescence when only a few primary leaves had been formed, it is pointed out that the omission of the long normal period of preparation for flowering,—with the large stem, numerous compound leaves et cetera,—may have been due to a lack of water and salts, so that the ratio of organic to inorganic materials may have approached, in this seedling, the magnitude normally reached only after the manufacture of a large quantity of organic foodstuffs. Also, it appears that *Campanula rotundifolia* forms round leaves when the ratio of organic to inorganic material is small, and that the linear leaves appear only after this ratio has been increased by the manufacture of more organic substances.

In the more complex and difficult subjects of heterophylly correlation, and regeneration, which are treated to considerable length in this book, the same idea is expressed from time to time, namely that these mysterious phenomena are dependent primarily upon nutrient conditions within the plant, which may often be altered by a change in the environmental factors. The most valuable feature of the discussions of these difficult subjects lies perhaps in the clear descriptions of the cases themselves and in the logical statement of the general conditions under which the different phenomena seem to occur, without any attempt to express hypotheses regarding the deeper causal factors. Deeper theorizing may come with greater knowledge, it is at present well to hold clearly in mind the facts of the various cases as they actually occur.

Throughout this treatise Prof. Goebel continually emphasizes the prime fact, that teleological and adaptational "explanations" of these phenomena are worse than valueless because they are misleading. Wherever a purpose is apparent in the reactions of the plant this exists only subjectively in the mind of the observer. The plant merely "does that which, under definite conditions, it *must* do."

Munich, April 20, 1908.

BY B. E. LIVINGSTON.

SOME SEEDLINGS OF THE DESERT.

Two of the most common desert plants of the mesa central Mexico are the sotol (*Dasyllirion* sp.) and the Palma loca (*Yucca filifera*). Their seedlings, as is usual in the case of desert plants, are seldom met with, either on account of their small number, or because of the necessity of diligent search in order to find them. When found they frequently present points of interest at variance with the mature plants. For this reason the following notes are given.

Sotol.—The chief features of the seedling of this plant worthy of especial note are the contractile roots, found in a probably great number of monocotyledons, and the leaf arrangement. The compact character of the soil in which the sotol grows, dry and rocky as it is, would hardly give grounds for expecting this type of root, the degree of effectiveness of which would be interesting to know. The stem of the seedling is somewhat bulbous, after the fashion of an onion, but laterally compressed, and the leaves are arranged in two vertical rows, a phyllotaxy which becomes very markedly changed as the plant matures. The leaves in the plantlet in question are about 50 cm. long. Its age is unknown.

Palma loca.—A seedling 15 cm. from the base of the stem was found growing in a clump of brush. The shoot at the base has a diameter of 8 mm. sending up five leaves, the broadest of which has a breadth of 8 mm. The lowermost is probably the cotyledon. The juvenile leaves bear none of the filamentous marginal appendages, nor the strongly spinose apex, nor the color markings of the mature ones. The stem proper is of course very short, the leaves making up the height of the plant.

From the base of the stem arises the tap root, and, arising laterally from the stem are two other roots. All three of these are spindle-shaped, and, as a transverse section shows, are composed of cortical tissue, with the exception of the central cylinder, which, in a root having a diameter of 8 mm., is 0.5 mm. thick. The cells of the cortex are large and thin-walled, and secrete a mucilage. A dark red bark clothes the tuber, arising from a superficial bark-forming layer of cells derived secondarily from the most superficial cortical cells. The measurements of these organs are:

Tap-root spindle, 2.6 cm. long by 0.5 cm. diam.

The two others, 2.8 cm. long by 0.6 cm. diam.

2.2 cm. long by 0.8 cm. diam.

The lower end of each tuber is continued into a slender root, and from it also spring laterally two or three secondary roots, giving rise to still others of the third and fourth order.

That these tuberous developments of the early roots of this seedling are water-storage organs appears from the structure, relative size, and contents. No starch is to be found. Such distinctive organs are absent from the old plant, though, of course, the same function is taken up in other ways.

Ocotillo.—(*Fouquieria splendens*.)—A specimen 6 cm. in height, 3 mm. thick at the base, has a maximum diameter of 6 mm. at its thickest point, which is near the top. The plantlet is club-shaped, and is at least three years old, the

amount of growth in height per year being: 1st year, 5 cm.; 2nd. year, 5 mm.; 3rd. year 5 mm. Toward the close of the first year a few, not more than three, weak thorns were produced at the top of the stem, and three more, but more strongly developed (6 mm.) each succeeding year. A branching of the root took place just below the surface of the soil, a single tap root penetrating to some depth. Secondary anatomical changes in the stem resulted in the formation of the waxy bark, which, being fissured, exposes the chlorophyll-bearing tissues of the cortex as in the mature plant.

FRANCIS E. LLOYD.

THE BOTANICAL GARDEN AT PISA.

Under the guidance of Dr. Barsali I was able to spend a few hours of an afternoon in late February at the ancient Orto Botanico at Pisa, Italy. Leaving the broad riverside street at the northern end of the Ponte Solferino, one proceeds northward along the Via Solferino, directly toward the Duomo, with the swinging lamp "of Galileo," and the famous leaning campanile. About a third of the way to the Piazza del Duomo, on the right, are a group of grayish plastered buildings which contain the laboratories and museums for botany, zoology and mineralogy. A little farther on is a gate in the high wall which surrounds the botanical garden, and a ring at the bell brings a smiling Italian portiere, who opens the gate and shows one across the garden to the entrance to a building on the garden side.

The garden is not large, being only about 250 meters long and 75 meters broad, but there is hardly a square meter of it that is not used for the growing of plants. A large portion of it is laid out in rectangular beds containing representatives of the main families of flowering plants. At the northern end are a group of small greenhouses with a much crowded, but fairly representative collection of exotics.

The main plants to attract attention out of doors, at this time of the year, were the early spring flowers and the trees. Of blooming plants there were a surprisingly large number. Pale blue native crocuses and white and yellow species of *Narcissus*, both native and introduced for cultivation, together with young leaves on a number of shrubs and swelling buds on others, made the garden seem like an Illinois garden in late April or early May. Several species of *Helleborus* were in bloom, and a fine clump of *Iris stilosa*, with delicate purplish blue flowers, was conspicuous. The native *Anemone coronaria* was in blossom. Hyacinths and tulips were coming into bloom, and the garden hands were busy with the planting of seeds and other preparations for summer.

A small tree of *Citrus chinensis*, with small leathery leaves and a great load of tiny oranges, was the first thing to attract my attention. The fruit is rather sweet, but also strongly flavored with orange oil. The tree is exceedingly attractive in appearance and thrives well in this climate. *Citrus vulgaris* is also present in the garden, the fruit appearing like the mandarins grown farther south. The oldest tree in the garden is a *Quercus rotundifolia*, with a trunk about a meter and a half in diameter. It was planted in 1770. Other large trees were a giant cedar of Lebanon, planted in 1782; several Ginkgos, planted in the same year, the largest of which has a diameter of about 1.4 meters; a *Magnolia grandiflora* some 60 centimeters in diameter; an *Araucaria bidwellii* about 30 centimeters; an *A. imbricata* about 20 centimeters; and an *A. braziliensis* about 15 centimeters. *Araucaria bidwellii* and *A. braziliensis* both fruit in the garden.

BURTON E. LIVINGSTON.

Munich, Germany, March 11, 1908.

THE VIABILITY OF SEEDS.

Some interesting observations have been made recently at the Arizona Experiment Station concerning the viability of seeds of various economic plants after continuous prolonged submergence. These experiments were suggested by conditions which obtain in the Colorado River Valley in Southwestern Arizona, which, as is well known, is subject to an annual rise in May and June from the melting of snows in the mountains near its source. By virtue of this it overflows its banks, covering its flood plain to a depth of one to several feet with water, very much like the historic Nile of Egypt. There being practically no rainfall in this section of Arizona and adjacent Mexico during the spring and summer months, certain annual crops that are grown by other means than systematic irrigation are sown on these flood plains before the season of high water begins. With the clearing away of the flood the seedlings appear through the soft, sedimentary mud which is rich in nitrogen and mature a crop before the land becomes too dry for favorable plant growth.

In the experiments noted the seeds were sown in soil in the usual manner and flooded to a depth of twelve inches for a period of thirty-eight days, which is about the period of average submergence over the lower flood plain of the Colorado River. With this treatment the percentage of germination of normal seeds obtained were as follows: Bermuda grass, 42; Johnson grass, 45; amber cane, 45; wild hemp (*Sesbania macrocarpa*), 75; Japanese rice, 36; Honduras rice, 23; sugar beet, 16. No germination resulted with such plants as oats, rye, corn, millet and Jerusalem corn after more than a few days' submergence. When the period of submergence was extended to fifty days, the percentages of germination were as follows: Bermuda grass, 14; Johnson grass, 23; amber cane, 45; Honduras rice, 23; wild hemp (*Sesbania macrocarpa*), 13. One hundred per cent of radish, rutabaga, sugar beet and tomato seed, 75 per cent of

cabbage and celery seed, and 33 per cent of watermelon seed germinated after being under water twenty-one days. In this latter instance, however, the seeds were not in soil.

Certain Indian tribes, in particular the Cucopa Indians, sow the seeds of Sonoran millet (*Panicum sonorum*), which is a robust annual much resembling old witch grass (*Panicum capillare*), in the mud of the Colorado River delta as the water recedes. From the seed of this plant a meal or flour is made, while the coarse straw is used for feed for animals.

The so-called wild hemp is in reality a member of the pea family; its seeds endure submergence admirably and begin growth as soon as the flood disappears. In the course of the summer the plants which are annuals attain a height of fifteen or twenty feet; their deep and almost impenetrable thickets or jungles are limited to areas that are subject to annual overflow.

J. J. THORNER.

Univ. of Arizona, July, 1908.

MINOR NOTES AND NEWS.

North American Trees. By Nathaniel Lord Britton with the assistance of John Adolph Shafer.—Henry Holt & Co., 1908. American Nature Series.

The first regret in taking up this book is that it could not be made to include the shrubs as well as the trees; but without them it is a bulky volume of 894 pages, bound in the heavy form in which its publishers take delight, and as it stands will never be slipped into the pocket as a field companion.

As stated by the author, it is designed to describe all the kinds of trees known to grow independently of planting in America, north of the West Indies and Mexico, and to illustrate them by figures showing the characters of foliage, flowers and fruit. Good photographs illustrating the habits of growth of various species have also been introduced and add substantially to its value.

The task proposed has been so well carried out that the work will at once become a necessity, especially to those who have frequent occasion to identify American trees and are not within reach of the facilities offered by herbaria and libraries. The book possesses the great advantage of being written in less technical form than is usual in botanical works and with the numerous illustrations renders the recognition of a large part of the species described a comparatively simple matter. In the nature of things it is not to be expected that all of the 63 oaks and 51 thorn trees will be easily recognized except by trained botanists, nor, on the other hand, that all who have had such training will be able to concur with the writer in his treatment of these groups.

The brief account of distribution and clear presentation of distinctive characters, the few lines indicative of economical relations, the enumeration of common names now in use, and the illustrations give in handy form just the information that is wanted and combine to make this one of the most useful of Dr. Britton's works.

V. M. S.

The last sentence in the paragraph next to the last on page 112, May number of the PLANT WORLD, should read "For details of distribution, temperature, precipitation, light intensity, etc., will undoubtedly have to be considered, as well as the geological history of the region and of the plants involved."

Mr. A. A. Heller has been appointed assistant botanist to the Nevada Agricultural Experiment Station and took up his new duties on June 1.

Oswald Weigel, the well-known publisher and book dealer of Leipsic, Germany, has founded a new journal entitled "The Herbarium," which is to be issued at irregular intervals and will be sent free to any one desiring to receive

it. As indicated by its heading, the new publication is designed to facilitate exchanges of preserved plants, aid in the distribution of collections and in development of herbaria. The publisher wishes to receive botanical papers of all kinds.

The MacMillan Company of New York have recently issued a small volume on "Soils and Fertilizers" by Professor Harry Snyder of the University of Minnesota, which in addition to a general discussion of the physical properties, formation and composition of soils etc., includes a section devoted to experimentation and laboratory practice.

The third edition of Willis' Manual and Dictionary of the Flowering Plants and Ferns has recently come from the Cambridge University Press. Editions one and two were in two volumes, which have been combined in the present edition. A large amount of new material has been included and sections on methods and outfits for collecting and field work have been added. The author has had the co-operation of many of the leading botanists in England in the revision and preparation of the book.

Dr. C. S. Gager, Director of the Laboratories of the New York Botanical Garden, resigns that position September 1st to accept his election as Professor of Botany in the University of Missouri. Professor Gager is now reading final proofs of a volume dealing with his extensive experiments upon the influence of radium upon plants.

Dr. A. R. Schouten has recently presented a thesis to the University of Amsterdam in which he sets forth the results of an examination of the mutability and variability of the evening primroses. Five new mutants of Lamarck's evening primrose were obtained and many interesting observations made on those already known, including *Oenothera gigas*, which has been seen to appear but rarely. Dr. Schouten confirms Shull's conclusions that phylogenetically younger or more recent characters are more variable than older ones,

but he finds no notable difference between the general variability of a stable species and one which is in a state of mutability.

A masterly work on bud-variation by Dr. P. J. S. Cramer has recently appeared in the proceedings of the Scientific Society of Holland. By the examination of literature and of living plants the author has brought together the authenticated facts concerning sports in over six hundred species, and the availability of this data has enabled the author to present a comprehensive view of the subject that will make this book the most valuable which has yet appeared dealing with this phase of phylogeny.

Prof. H. B. Humphrey (B. S. Univ. of Minn., 1899 and Ph. D. Stanford University, 1907) has recently been appointed assistant professor of botany in the State College of Washington, and also assistant botanist of the state agricultural experiment station, both institutions being located at Pullman, Washington.

Of the various exercises already held and planned by various societies in commemoration of the fiftieth anniversary of the appearance of the "Origin of Species," by Darwin and Wallace, those held by the Linnean Society of London must rank among the most notable, especially as it was before this Society that the first essay entitled "On the tendency of species to form varieties; and on the perpetuation of varieties and species by natural means of selection," by Darwin and Wallace, was presented on July 1, 1858. The commemoration exercises were made notable by the fact that Wallace was able to attend in person and gave a description of the actual relations existing between Darwin and himself in elaboration of the idea of natural selection. The proceedings, which will include a lecture on "The Jurassic vegetation of the world: a study in plant-migration," by Professor Seward, will be published in a separate volume.

An interesting book by Diels (1) has for its general topic the relation between the vegetative and sexual functions in the flowering plants. After summarizing our knowledge of the conditions effecting reproduction in these forms, he points out that between the higher and lower plants there is no important difference in the condition inciting sexual reproduction, and in the flowering plants both the time and the stage of development at which sexual reproduction occurs is conditioned by external influences. Sexual maturity in the flowering plants, Diels maintains, is, contrary to common belief, independent of the vegetative stages which these plants usually pass through. Necessarily a certain minimum of vegetative structure is necessary (perhaps for merely mechanical reasons) before the generative parts are produced, but that this is much less than is usually considered the numerous examples which the author brings together clearly show. Diels follows Goebel in the use of the terms "homoblastic" and "heteroblastic" to distinguish between those cases in which the progressive stages in the development of the individual differ but slightly and those in which the stages are more or even quite distinct from each other, and introduces the new term "helicomorphy" to include Goebel's two terms "juvenile forms" and "successive forms" in heteroblastic plants.

The bulk of the book is devoted to a discussion of the relation between helicomorphy and generative maturity in heteroblastic plants. A wealth of illustrative material is presented and there seems good evidence for the authors contention that flowering far from being the terminus of heteroblastic development may be induced at any stage.

A chapter is given over to a discussion of the phylogenetic significance of helicomorphy which the author considers as without value. Discussing the "biogenetic law,"

(1) *Jugendform und Blütenreife in Pflanzenreich*, Von. Dr. L. Diels, Pub. G. Gebrüder Borntraeger, Berlin.

that ontogeny repeats phylogeny, Diels condemns this in no uncertain terms, he declaring that it can satisfy but the needs of the imagination. The reviewer cannot refrain from remarking that while this seems to be the place to which many, especially physiological investigators, would now relegate this theory, yet it is possible that all the facts concerning it are not being taken into account. If the theory is not true, at least in part, i. e. if certain structures and stages occurring in the development of the plant do not clearly indicate ancestral structures and relations, the bulk of modern morphological theory must fall to pieces.

While there is not much essentially new in the book, the author has gathered together a large amount of very suggestive material and has presented it with unusual clearness and balance.

W. B. M.

THE PLANT WORLD

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TRANSPIRATION AND WATER STORAGE IN STELIS OPHIOGLOSSOIDES SW.

By FORREST SHREVE.

The work of Schimper has shown that even in the most pronounced tropical rain forests one may expect to find xerophilous types of vegetation among the epiphytes which inhabit the upper limbs of the tallest trees, while upon the lower limbs and trunks may be found hygrophilous plants, frequently including species which also grow in the deep shade of the forest floor. In savannas, or other tropical regions with a low and well distributed rainfall, the wealth of epiphytic vegetation is no less than in the rain forest but is made up solely of the xerophilous types. The contrast in the climatic conditions to which the high and low epiphytes are subjected is as great as that which differentiates regions of savanna and rain forest. For the high epiphytes there is a brief period of rainfall each day, followed, or more often preceded, by many hours of intense insolation, lowered humidity and wind. For the low epiphytes there is shade and high humidity together with almost constant supplies of water held by the beds of mosses and hepatics covering the trunks and limbs. At mid-heights there are conditions intermediate between these, an intermittent and uncertain supply of water, together with conditions which are only slightly less favorable to a high rate of transpiration than are those in the topmost limbs. The xerophilous epiphytes, like the perennial plants of the desert, fall into two classes,

one in which there are merely structural provisions for the reduction of transpiration, and often for the external holding of water, as in the tillandsias, and a second in which there are water storing tissues, as in many Orchidaceæ and Piperaceæ. The first class makes up the great bulk of the epiphytic vegetation of the savannas and the principal part of that in the extreme top of the rain forest. The second class predominates at mid-heights in regions with a heavy and well distributed rainfall. Here again there is a close analogy between the distribution of the two classes of epiphytes and of desert perennials in relation to climate. The epiphytes devoid of storage tissue are adjusted to regions in which there is a low but constant rainfall, while each day presents to the water storing epiphyte a miniature duplication of the conditions which extend over many months for the desert cactus.

While making some studies in the montane rain forests of Jamaica in 1906 the attention of the writer* was attracted by the rich assemblage of epiphytic types to be found there and the exactness with which they are distributed in relation to the vertical differences of climate in the forest. The hygrophilous epiphytes of the lower levels are chiefly Piperaceæ and ferns, notable among which are numerous species of Hymenophyllaceæ. At mid-heights occur a few species of water storing Piperaceæ and a rich representation of Orchidaceæ, together with a few ferns and phanerogamic plants which have no peculiarities of gross anatomy. In the uppermost branches the Bromeliaceæ are represented by a few species, of which one—*Guzmania tricolor* Ruiz & Pav.—is very common, and with it grow a number of small ferns and mosses, hepatics, lichens and blue-green algæ. In very many of the water storing Orchidaceæ the storage tissue is located in the fleshy roots, while the leaves are thin, as in *Dichaea glauca* Lindl. and *D. trichocarpa* Lindl. In

*Then holder of the Bruce Fellowship in the Johns Hopkins University.

others there is a mass of storage tissue in a bulb-like swelling at the base of the leaf, as in *Epidendrum cochleatum* L. and *Liparis elata* L., while in still others not properly belonging in the same class the water is stored externally in a tank formed by the inflated bases of the leaves, as in *Govenia utriculata* Lindl. Leaf storage of water is also common, but usually occurs together with one of the other types. In *Stelis ophioglossoides* Sw., *Lepanthes tridentata* Sw. and *L. concinna* Sw. the leaves alone serve as storage organs. *Stelis* was therefore found to be a convenient form in which to study the amount and rate of water loss, with a view to ascertaining how long such plants can survive without opportunity to absorb fresh supplies of water, and what relation exists between the normal rate of transpiration and that obtaining during conditions of severe drought.

Stelis is a plant with a small rosette of leaves which are elliptical, 10 to 15 cm. long, 2.5 to 3.5 cm. wide and about 4 mm. in thickness. The water storing tissue occupies nearly two thirds of the thickness of the leaf, lying above the chlorenchma, in which there are also a few scattered cells of identical appearance with the main storage cells. All of these are characterised by walls which are sinuate in cross section, with alternating thinner and thicker bands. The epidermis of both surfaces is very heavy, with a thick cuticle on the upper and deeply sunken stomata on the lower surface only. The habitat in which *Stelis* is most abundant is the horizontal or nearly horizontal limbs at mid-height between the floor and the canopy of the forest.

One of the determinations of transpiration rate in *Stelis* was made by the potometer method, the apparatus being set up in the laboratory at Cinchona where during the course of the following readings the temperature varied from 67° at 2 p. m. to 62° at 8 p. m. and 58° in the night, the humidity from 86% at 1 p. m. and 90% from 4 to 10 p. m. to 92% in the night. The leaf used had an area of 29 sq. cm. and took up 229 mg. of water according to the total

of the potometer readings, and lost 10 mg. according to weighings at the start and close of the test, which indicates that the inherent error of the potometer method is even greater than usual in the case of leaves with water storage tissue. All figures given show the rate of loss per 100 sq. cm. per hour.

<i>Period</i>	<i>Rate</i>
1.30 to 2.00 p. m.	46.5 mg.
2.00 to 3.00	72.4
3.00 to 4.00	95.2
4.00 to 4.30	78.2
4.30 to 5.30	39.1
5.30 to 7.00	34.3
7.00 to 8.00	26.0
8.00 to 10.00	25.8
10.00 to 7.00 a.m.	19.7
7.00 to 1.30 p. m.	57.4

While these data serve to give a good notion of the daily play of the transpiration rate, they are deceptive as to the absolute amount, as shown by another set in which an entire plant with unbroken root system and four good leaves was placed in a jar of water sealed with plastocene. This test was carried out first in the laboratory and later out of doors under natural conditions of the rain forest. In the first case the temperature ranged from 57° to 69° and the humidity from 75% to 90%. In the second case the weather was cloudy with intermittent fog and a good breeze, the temperature ranging between 60 and 70 and the humidity between 85% and 92%.

<i>Period</i>	<i>Rate</i>
2.00 to 5.30 p. m.	125 mg.
5.30 to 9.00	42
9.00 to 6.30 a. m.	17
8.00 a. m. to 5.30 p. m.	159

These figures serve to show what is much more nearly the normal rate of transpiration in *Stelis* at such times as it is abundantly supplied with water, but not subjected to sunshine. An opportunity to ascertain the rate under insolation

could not be secured during the time that these experiments were going on. In order to compare the rate of transpiration when the water supply is cut off, and in order to see how long the leaves of *Stelis* are able to persist under such conditions, three sound leaves were removed from a plant growing under favorable conditions of water supply, the cut ends of their petioles were sealed with vaseline and the following series of weighings were made:

	Actual weights (in grams).			Average loss per day.
	I.	II.	III.	
Nov. 28	3.015	3.620	4.430	
Nov. 29	2.953	3.523	4.381	.069
Nov. 30	2.910	3.435	4.350	.054
Dec. 1	2.860	3.395	4.315	.042
Dec. 3	2.777	3.273	4.220	.050
Dec. 5	2.685	3.220	4.140	.037
Dec. 9	2.600	3.120	4.015	.026
Jan. 17	1.890	2.505	3.035	.019

The most noticeable feature of these figures is the low rate of water loss on the first few days as compared with that found even in the potometer experiments, the average for the three leaves on the first day being 69 mg. as compared with the total loss of 229 mg. in the leaf on the potometer, which was of nearly the same area. How much this immediate checking of the rate may be due to closing of the stomata and how much to other physiological controls as well, I am unable to say. A second noticeable feature of the figures is the fact that the daily loss of water grew less and less in both absolute amount and in percentages of the total weight, which is, however, no more than would be expected.

The three leaves were lying during the entire duration of the weighings on a table in the laboratory at Cinchona. Returning to the experiment after an absence of several weeks on the 17th of January, I found that the leaves had become limber and somewhat wrinkled on the surface. In order to test their capacity to reabsorb water the vaselined

ends were cut from the petioles, and the leaves were reweighed for a number of days with the following results:

	Actual weights.			Average gain per day.
	I.	II	III.	
Jan. 17	1.878	2.492	3.024	
Jan. 18	2.390	2.860	3.305	.387
Jan. 19	2.440	2.902	3.350	.046
Jan. 20	2.480	2.910	3.410	.036
Jan. 30	2.450	2.920	3.523	.001

While there was some power left in the leaves to absorb water, their failure to take it up continuously, so as to restore the original weight, shows that the 50 days during which they had been isolated was too long a period for them to withstand. The power of entire plants of *Stelis* to tide over periods of drought was not tested, but is probably not much greater than that of the isolated leaves.

For the sake of comparison with *Stelis* two plants of *Guzmania*, still attached by their holding roots to the branches which they had inhabited, were brought under roof at Cinchona and kept for 53 days without wetting. The plants lost a number of the outer leaves of their rosettes, but were still alive at the end of the test, as evidenced by the growth of new leaves when they were again supplied with water. *Guzmania*, therefore, even in the absence of a stored supply of water is capable of withstanding prolonged drought better than the orchid in which there is a small supply of water that is conserved during drought by a marked cutting down of the transpiration rate. This is in accord with the distribution of *Stelis* and *Guzmania* in the rain forest, where the former occupies mid-heights and the latter, while not absent from mid-heights, is commoner in the highest limbs. The relation between these two types of epiphytes as respects ability to withstand drought and as respects vertical distribution is one which holds, with minor modifications, for all members of the two classes of water storing and non-storing epiphytes. All of the water storing Orchidaceæ and Piperaceæ of the Jamaican montane forests are associated

with *Stelis* at mid-heights, while the associates of *Guzmania* on the highest limbs are other non-storing types.

The meteorological records for *Cinchona* show that there are rare occasions during the relatively dry seasons in early spring or mid-summer when no rain falls for several days, or even in very rare cases for several weeks. During these periods the atmospheric conditions would favor a much more rapid desiccation than that which took place in the above tests, a fact that would be partially offset by the availability of water from the substratum during the earlier part of such unusual dry spells. *Guzmania*, under these same conditions, would soon lose all the water held externally by its rosette of leaves, and in default of the power to absorb further water from the substratum it would suffer drought comparable to that of the experiment, or even more severe in view of its exposure to insolation.

In the savannas of the south coast of Jamaica there are very many epiphytes of the non-storing type which are without provision for the external retention of water, as *Tillandsia usneoides* L. and *T. recurvata* L. The ability of these forms to withstand prolonged periods of drought is too well known from common observation to need experimental proof, although it must not be forgotten that the copious dew of the savanna regions forms an additional supply of water for these forms, and they are also able to avail themselves of the humidity of the air.

The water storing epiphytes are restricted in their distribution not only by the climatic conditions themselves, but by the occurrence of favorable water-holding substrata on the limbs of trees. In the rain forests the deep mats of mosses and such hepatics as *Ptilidium* and *Trichocolea*, with their finely dissected leaves, serve to retain a reserve of water from which the orchids are able to absorb slowly for the replenishing of their storage tissues. In the savanna regions water storing forms are confined to the lower and larger limbs of very large trees where there are accumulated

masses of humus material due to the decay of preceding generations of non-storing types. In all locations the non-storing types with rosettes for the external retention of water are found in places where there is no water-retaining substratum, their supply of storage water being caught as it falls.

A comparison of the rates of transpiration in *Stelis* when supplied with water and when subjected to drought by the removal of the leaves, indicates that it is able to cut down its water loss to such a low point that its reserve will suffice to meet the demands of transpiration for a period something short of 50 days. The velamen is not well developed in the roots of the *Stelis*, which are slender as compared with the roots of most epiphytic orchids, and are invariably to be sought beneath mosses, bark or debris, while roots with velamen are just as often found creeping over naked limbs or hanging free. The external supply of water is, then, of almost as great importance to the plant as is its own store. When external water is abundant transpiration goes on actively, and in amount not greatly different from the current absorption day by day. When the external supply is cut off the transpiration rate is at once lowered and the plant enters upon a period of reduced capacity for vegetative activity.

Desert Botanical Laboratory, Tucson, Arizona.

SOME FEATURES OF THE ANATOMY OF GUAYULE (*PARTHENIUM ARGENTATUM* GRAY).

By FRANCIS E. LLOYD.

There has recently appeared a paper by Dr. H. Ross* dealing with the anatomy of the Mexican guayule, a plant

*Der anatomische Bau der Mexikanischen Kautschukpflanze "Guayule", *Parthenium argentatum* Gray. Ber. d. Bot. Gesell. 26a: 248-263. Ap., 1908.

which has economic interest on account of the fact that the rubber which it secretes has induced the investment of a large amount of capital in Mexico. Dr. Ross spent some time during 1906 in Mexico studying the plant, and has given us some of his results in the paper mentioned.

While in many points the writer finds himself in harmony with Dr. Ross, there are certain matters on which he finds himself in disagreement, and the purpose of this present writing is to give a summary in English of Dr. Ross' contribution to our knowledge of the plant in question, and in addition to record in brief form the views of the writer.

Reproduction. Ross points out that in most cases the plant, in being gathered, has been pulled up by hand, a clumsy method which results in breaking off the roots, which are left in the ground and then die. It is true that the method of pulling up by the roots has been used largely, but it is of interest to know that a cutting tool (the "*talacho*") is more and more being used for the purpose. This more modern method brings it about that practically all the root system is left in the ground, and, especially in the event of rain, new shoots promptly appear in very many cases both from any portion of the stem that may happen to be left, and from the severed roots also. But there is no difference between a severed root and one left in the ground by breaking off, save that, when broken off, the pieces left are buried rather deeply in the soil, and have less bulk. Now as a matter of personal observation, all the roots broken by pulling up the plant do not die. I have pulled up plants myself, and in a few months have found new shoots growing from the roots left in the ground. There were only a few of them, but a total lack of rain during the period of observation probably accounts for this. A much larger proportion of new shoots are found to sprout out after cutting, and, as Ross observes, in 6-10 years sufficiently strong plants have grown, only that 6 years

is rather too short a time. The seeds, however, Ross continues, germinate more readily in the soil loosened by pulling, and this may be true enough, though I have found that the seeds germinate in such numbers in unloosened soil that the advantage on this account appears to have been inferred on *a priori* grounds. I have found as many as eight seedlings on one square inch which had germinated on soil packed by six months alternate rain and baking—chiefly baking, in view of the low rainfall. They have been seen to germinate in a soil the surface of which was hardened to a crust by salts. The question, therefore, would appear to be one which can be answered better after a considerable study of an area of guayule which has been treated by the method of pulling. Observation leads one to believe that shade is a more potent factor. More seedlings are usually to be found in the shade of a large guayule bush than anywhere else, and very often one finds a half-dozen plantlets from one to several years old very near to the presumable mother plant. This brings us to the question of the relative importance of seed in reproduction, which, according to Ross is minor. The actual count of seedlings in the field to the mind of the reviewer clearly negatives the view expressed by the phrase “apparently weak reproduction by seed.” In some areas to be sure, there is a weak reproduction by seed, but the relative number of large and small plants (seedlings) varies in all ratios, and, by count, has been found to be from 300 plants of less than 0.12 of a pound to 5 such, *all seedlings*. As I have elsewhere shown, a weak germination, or at least subsequent growth in the resultant seedlings, occurs on rather steep slopes of a certain character, where is to be found a shallow soil, but here a vegetative method, by means of new shoots from the roots of plants *in situ*, compensates for this. Take it by and large, a close study of field conditions leads inevitably to the view that seeding plays a most important part in the reproduction of the plant. Ross in this connection states that many attempts have been made at

the culture of the plant, and these have shown that after many failures the plant may be reproduced (in cultivation?) both by seeds and by cuttings. Ross does not mention the kind of cuttings. My experience has failed to produce growing cuttings save of one kind, and it would be interesting to know if Dr. Ross' experience has been the same.

Secretion of rubber and water. The problem of the relation of irrigation to rubber secretion is raised by Dr. Ross, who observes that, while with increase of water the plant grows more rapidly, the matter of secretion under similar circumstances has not been investigated. It is observed that experiments are in progress, in the meantime, in certain German colonies in S. W. Africa, which country offers prospects for the culture of guayule. Later in the paper the important fact is pointed out that the rubber is secreted, not as in the commoner rubber plants of cultivation, such as *Castilloa*, in tubes (latex tubes), but occurs in nearly all the cells of the ground tissue: in the pith, medullary rays and cortex, which tissues in winter are densely filled with the material. The leaves have very little, and the wood none. Ross is the first to point out this fact, a very important one physiologically as well as economically, for this it is which favors a mechanical process of extraction.

The facts are now at hand to enable us to give a clear if not strictly quantitative statement of the relation of rubber secretion in guayule to water supply, or, as it would better be put, to rate of growth, as this appears to be the more fundamental relation. If we examine the tissues of field plants in the period of rapid growth following rainfall in the summer, we shall find a clue to the question which Dr. Ross indicates. In a newly grown stem of say 5 cm. length, taken before induration of the tissues has set in, no rubber will be found at all except very near the base. In about two months we may note the first appearance of rubber in the pith cells, within about 10 mm. of the base. At 6 mm., 4 mm. further down, a similar small amount, appear-

ing as flocculent granules, may be observed in the cortex. During the period of growth, then, and for some time thereafter, the tissues of newly formed stems are practically devoid of rubber. This condition, however, is not confined to the new stems. Older stems have, during the same time, been adding secondary tissues, and these too are devoid of rubber. The outer parts of the medullary rays contain none, nor do the new cortical tissues. The zone of rubber-free tissue shows clearly under a low magnification. Precisely the same physiological relations are shown by plants which have been grown rapidly with abundance of water, except that quantitatively they are much more marked. If, however, plants be grown slowly, even with all the water it is possible to give them, rubber appears, though not in such quantities as occur in field plants subjected to drought, at least in the time that they have been under observation. In addition to the physiological relation, however, there are other changes which take place in irrigated plants made evident in the anatomical relations. The wood is much more rigid, and this stands in relation to the thickness and depth of the medullary rays, which are much greater in field plants, which also have a thicker cortex, and larger and more numerous resin canals. *Mutatis mutandis*, the wood of an irrigated plant is three times more rigid than that of a field plant when fresh and freed from the bark (11:3.5) and this ratio is changed to 2:1 after drying. In stems of equal total diameter, the ratio of wood to bark is 6.25:2.15 in irrigated, and 5.5:2.9 in field plants, radial measurements in mm., while in stems with bark of equal thickness the ratios are 6.25:2.15 (irrigated) and 2.75:2.15 (field). Without entering further into details which await fuller publication, it may be said that the changes observed are quite remarkable and have an important economic bearing. It may be observed, however, that growth precedes rubber secretion, and the more rapid the growth, the longer it takes for the laying down of rubber to catch up with it. Water in abundance

appears therefore not to prohibit rubber secretion, but to slow it down. At the same time, profound anatomical changes are induced which may effect the total amount of possible secretion. To what extent these changes may be offset by later reactions it remains for time to indicate.

Secretion of rubber and size of plant. Ross states that the rubber producing stuffs are not extensively produced, and only very slowly at first, in small plants. For this reason it does not pay to work plants less than ten years old.

The statement is one very much in vogue in Mexico. I have heard it said frequently that small plants contain no rubber. The amount of rubber varies in different plants from different habitats, as would be expected from the facts above pointed out, but that there is such a difference between large and small plants from the same habitat as one must be led to infer from the statements made, I find to be open to question. I have examined microscopically, and by mechanical extraction seedlings of all ages, from one year up, and it is very difficult to believe that the relative amount of rubber is as little as is supposed. That it would not pay to gather small plants is true for reasons of economy in handling alone, disregarding the far more important reason of reforestation.

Resin canals. Ross describes correctly the occurrence and distribution of the resin canals in the stem, where, both in the pith and cortex, at the growing apex, they arise very early by splitting, and usually stand in relation to the bundles. Those of the pith are and usually remain cylindrical, while those of the cortex soon become compressed at right angles to the radii. Canals are found also in the leaves, on both sides of the stronger bundles, and on the wood side only of the weaker ones. The lining cells have dense contents.

In addition to these observations, I have found certain peculiarities which should be noted. Pith canals do not occur in the epicotyledonary stem for the first few internodes, nor

are they present in the hypocotyl. They are absent too, from the basal portion of shoots ("retoños") which arise from the root. Another very marked feature is the intrusion of parenchymatous tissue by lateral proliferation into the larger and older canals. In the older stems, the outer cortical canals become stretched to surprising dimensions, and often become wholly or partly filled with tissue. The effect, we may presume, is to close the canals which are about to be cut out by the inner periderm, and so prevent leakage of resin.

In the hypocotyl the primary canals arise in the endodermis, one opposite and, by virtue of its origin, just outside each of the four primary bundles. Later these become secondarily removed to a position further out, this change being accompanied by others involving the establishment of a secondary starch-bearing zone of cells. In the root, on the other hand, the primary canals are found to be in two groups of two to three each, each group opposite the primary phloem, and arising, again, in the endodermis. All the secondary canals arise in connection with the secondary bundles, at the outer periphery of the phloem. As Ross observes, there are fewer canals in the root than in the stem, where they arise outside of the endodermis secondarily, which appears not to occur in the root. It may be pointed out here that these relations hold in the main in the mariola (*Parthenium incanum*) and in certain herbaceous annual species of the genus.

The mechanical system, including wood. As pointed out by Dr. Ross, it is very difficult if not impossible to determine the age of a guayule plant by the ring structure of the wood. Annular markings may be detected, but I have not been able to trace them clearly in sections. The suggestion is made, however, that the zone formation in the bast may serve as an index, and this in a rough way appears to be the case. The number of zones is, nevertheless, related rather to the thickness of the stem than to the age, the thickness being related to the number of superimposed branches,

Furthermore the cutting out of bast in older stems interferes with the usefulness of the method, though it must be said that, in practice, this is of little importance since such large plants will not be grown. Probably, when rightly understood, the method suggested by Ross will serve well enough, especially when checked by the use of other marks.

As shown by the same author, bundles of hard fibers occur from time to time, alternating with secondary resin canals and sieve tissue, in which these canals arise. These occur also in the pith of the stems of the inflorescence. It would appear from Ross' account that these mechanical elements in the pith are confined to the peduncle and its branches, but this is not the case. Bundles of fibers, exactly similar to the cortical bast fibers, appear within the pith just inside the primary wood in ordinary stems, sometimes somewhat removed, and separated from the wood by a few small pith cells, but more usually juxtaposed. After some degree of secondary thickening, the similar appearance of the mechanical elements of the wood proper and those of the pith prevents their ready detection. It is these fibers which run up into the peduncle, and, spreading around the wood bundles, join the cortical bast fibers and so close the bundle, thus producing a very stiff though slender flower stalk. The same structure may be seen in the annuals above mentioned, but it is further elaborated in them.

A further peculiarity of the pith is its local induration, by thickening of the cell-walls in irrigated plants, a circumstance which may contribute to the strength of the stem, which is remarkably more rigid than that of a field plant.

Among other details noted by Dr. Ross, we shall mention further only the slowness with which the bark is formed and the persistence of the cortical structure. Even with the formation of inner periderm, the cutting out of tissues is not rapid. The cork is, however, visible quite close to the growing point, the distance being related to the rate of growth.

THE HASHISH PLANT IN ARIZONA AND MEXICO.

By HERBERT BROWN.

While in charge of the Territorial prison at Yuma, the writer had cause to become familiar with a plant known as "marijuana." It was said to be an exceedingly dangerous customer when turned loose among men confined in penal institutions, more especially so among those of the lower class, by whom it is used as a substitute for morphia and opium, or rather it should be said they are substitutes when marijuana is not obtainable. When dried and crushed to the size of ordinary Mexican smoking tobacco, which it much resembles, it is ready for use. Commonly it is mixed with an equal portion of tobacco and when made into cigarettes has a market value of 25¢, 50¢ and \$1.00 each, not according to demand but to supply. Its presence in penal institutions is as much to be dreaded as the plague, and every effort possible is made by the authorities to keep it out. Under its baneful influence reckless men become bloodthirsty, trebly daring, and dangerous to an uncontrollable degree, and at least one lamentable tragedy in the territorial penitentiary is directly chargeable to it.

Having seen this plant in its dried form and heard so much of its hypnotic power for evil I was quite anxious to meet with it under its natural conditions, and having ascertained that it was cultivated to a limited extent in the vicinity of Tucson I sought the advice and assistance of an ex-convict whom I knew to be living here, and whom I further knew would be informed if such were the case. At first he was inclined to be non-communicative, but in due time he "loosened up," and took me to where it was growing. In all there were probably two dozen plants of various sizes. Dr. D. T. MacDougal, director of the Carnegie Botanical Laboratory, was next called into the case and he at once identified the plant as a species of hemp, *Cannabis indica*.

This was a revelation to the writer. Had a cobra raised his spectacled hood the surprise could not have been more startling. Here was the Oriental dream making, murder inspiring bhang of Indian song, story and thuggism, taking root in the far west; a household plant grown at every cottage door in the vale of Kashmir found thriving before the door of a mud hovel on the desert begirt banks of the Santa Cruz. The same question that agitated the wondering sire of "Little Breeches," "How did he get thar? angels," was answered by my convict friend who assured me that it was of comon growth in central and southern Mexico, where however, "taboo" had been placed upon it by the Mexican Government. Under flaring head-lines a recently published newspaper article recites the seizure of "eight large boxes of marijuana, the largest collection of the national dope weed of the Mexican peon ever captured in a single haul by the police, and perhaps the greatest quantity of this weed ever seen at one time out of the field." * * * "Enough of this brain-wrecking weed was seized to have caused any number of murders had it reached the poor persons for whom it was intended." * * * "The effects of marijuana are like, but worse than those of opium. It has the tendency to craze the brain of the smoker. The weed has a pleasant aromatic odor and its immediate effect when smoked is considered more seductive than opium, but in the end it produces a murderous mania. To fight its use among soldiers is one of the hardest tasks before the army authorities."

If sold in the tedejons of Mexico, and detected, the tendero is arrested, his store closed, his goods confiscated and he is either sent to the army or the penitentiary. In Tucson it is grown to supply the trade which amounts to, so my convict friend informed me, an average of \$2.50 per day. The Mexican railroad laborers, he said, use all that is grown here outside of what they are able to purchase at the drug stores. There are several small gardens border-

ing the river in which the plant is grown, but the fear of publicity and punishment leads the growers to suppress this fact where possible.

According to standard authorities, it appears that this plant, though recognized under several forms and names, is generalized under that of *Cannabis sativa*, and that it has been known and used, especially in India and China, from times most remote. In India, its apparent birthplace, its several preparations are known as bhang, gunja, or ganga, and churrus or charas. Bhang consists of the larger leaves of the plant on which an efflorescence of resinous matter has occurred. The leaves are in broken and partly agglutinated pieces, having a dark green color and a heavy but not unpleasant smell, and it is used for smoking with or without tobacco. When prepared in the form of a cake it is made into an intoxicating beverage by infusing in cold water and straining. Gunga is the flowering or fruit bearing tops of the female plants. It is gathered in stalks of several inches in length, the tops of which form a matted mass, from the agglutination of flowers, seeds and leaflets by the abundant resinous exudation which coats them. Churrus is the resinous substance separated from the plant. The preparation known as hashish used among the Arabs is similar in preparation to the gunja of India. It was, Herodotus says, used by the Scythians. They crept inside of huts and threw the seeds on hot stones. These gave off a virulent intoxicating smoke, by which the inmates were soon overpowered, and they howled with delirious delight.

Its narcotic properties were early known in India by various names expressive of its qualities, such as causer of the reeling gait, laughter mover, and so on. Royle suggests that it is as likely as any other plant to have been nepenthe, the assuager of grief. Its medicinal properties have long been known to the Chinese, as a surgeon of that nation is said to have used it as long ago as A. D. 220, and to have operated on patients while they were under its influence. In modern

materia medica and therapeutics it is stated that in large doses it produces a condition of mental exhilaration and disordered consciousness of time, locality and personality. This stage of excitement finally gives way to sleep, which may last several hours. Sensation is perverted and benumbed, and before sleep is produced there is more or less general anaesthesia. Upon the circulatory and respiratory systems the drug has but little influence. Although alarming symptoms follow overdoses no death from its use has been recorded.

A NEW METHOD FOR CULTURES OF ALGAE AND MOSSES.

In the course of a series of experiments on the relation of evaporation and soil moisture to plant growth it has become apparent that the porous clay cup described in Publication No. 50 of the Carnegie Institution and referred to in *THE PLANT WORLD* for Dec., 1907, and for Jan., Feb. and May, 1908, is exceedingly valuable in the growing of such algæ or mosses as need a solid and continually moist substratum. The difficulties of studying the behavior of algal forms which thrive on the bark of trees, moist stones and the like, are not at all inconsiderable. Such difficulties arise in good part from the trouble experienced in maintaining the proper moisture conditions. It is well known that porous clay offers a suitable substratum for the growth of such forms and the porous cup evaporimeter furnishes a simple device for keeping such a clay surface at a constant moisture content.

The porous cup, after being sterilized by boiling in water, is carefully filled with water or dilute nutrient solution, stoppered with a perforated rubber stopper, and connected by a tube through the latter with a bottle of the solution placed at a lower level. The algæ are then planted on the surface of the cup and the latter placed under a bell jar or other suitable cover which will reduce the evaporation. No

further attention is necessary excepting to maintain an adequate supply of water in the bottle. Under a bell jar very little water is lost, so that the apparatus can stand without attention for months. The cultures behave apparently as they do in nature. It is unnecessary ever to wet the plants by pouring water over them, and danger of mechanical disturbance is thus completely removed.

This method will recommend itself to workers who desire to study the effect of light, of various gases, and of dissolved salts on algal growth. It must be remembered, however, that the nutrient medium on the surface of the cup will gradually become more concentrated if the evaporation rate is relatively high, but it is easy to control evaporation so as to prevent this entirely or reduce it to a minimum. A certain amount of evaporation will, no doubt, be accommodated by backward diffusion of the solutes into the cup and eventually into the bottle.

The apparatus should be suitable for the growing of mosses from spores as well as for the germination of fern spores and the like. Even small seeds, such as those of certain grasses, and mucilaginous ones, such as those of mustard and other Cruciferae, can be germinated on the moist clay cup. Thus it is possible to obtain material for the study of root hairs, clean and free from soil. The apparatus is so simple and operates so automatically that it is adapted to the needs of teachers who desire good class demonstrations in a form involving a minimum of attention.

Algæ, mosses and fern gametophytes may be grown upon soil which is kept at a constant moisture content by the same apparatus, as described in the *Plant World* for Feb., 1908. A rather heavy soil, loam or clay, has been found most suitable for the growth of algæ and mosses by this arrangement. They thrive without attention for months at a time.—*Burton E. Livingston.*

Munich, July 15, 1908.

THE PROCLAIMED PLANTS OF VICTORIA.

The conditions by which a plant becomes a weed when it leaves a restricted range and becomes disseminated over wide areas by some unusually efficient agent for dissemination possesses much interest for the plant geographer.

The opuntias can scarcely be said to be weeds in any part of America, yet when taken to other countries propagation takes place so rapidly that much ground valuable for agricultural purposes may be occupied. This appears to be the case with the drooping prickly pear, *Opuntia monacantha*, in the state of Victoria, Australia. Concerning it, Dr. A. J. Ewart, the Government Botanist for that state, says in *The Journal of Agriculture of Victoria* for June, 1908:

“Every joint will strike root under favorable conditions, and both the ripe and unripe fruits will do the same. The joints may remain alive several months after cutting. They can be destroyed by boiling, and may then be fed to stock if care is taken to see that the spines, especially smaller ones, have come away. It is not, however, good food, being too bulky and watery. Otherwise it can be buried in pits and covered with soil, or piled in heaps and covered with quick lime. In South Africa spraying with arsenite of soda is recommended ($2\frac{1}{2}$ to 4 per cent. solution), but this is costly (probably £3 to £5 per acre in Victoria), and the plants need to be burnt off as soon as they have dried and before new shoots appear. Spraying the standing plants with dilute sulphuric acid in calm, dry weather is also fairly effective but less so than cutting.

This plant appears to be increasing in Victoria, and is spreading along the railways around the shores of Port Phillip Bay, where it is likely to prove a great nuisance or even danger if unchecked. The plant would without doubt do great harm in the Mallee district if allowed to spread there. Several other less common species grow in Australia,

and an account of them has been given by Maiden in the *Agricultural Gazette for New South Wales*, Vol. IX., p. 1002, 1899.

Proclaimed for the whole State, February, 1907."

This species of *Opuntia* is from South America and has long been a serious pest in Australia, but experiments being made in Texas, New Mexico and Arizona suggest that if proper methods of burning the spines were used the Australians might find in this dangerous weed a valuable supply of forage.

BOTANY IN THE MAGAZINES.

The languid indifference on the part of editors of popular magazines to facts in natural history has received another ludicrous exemplification in an article on the "Rootless Cactus of California," by Harry H. Dunn in the *Technical World* for July, 1908. Mr. Dunn's botanical effort reads as follows:

"Curious among vegetable growths of the new world, and one which is seldom seen of men, is the rootless cactus of the California desert. This plant, a round, compact growth, rolls about the level floor of the desert for some eight or nine months of the year, tossed hither and yon by the winds which blow with fierceness over all of California's sand plat during those months.

At the coming of the rains, or rather, the cloudbursts, which sweep the desert in its springtime, this cactus takes root, wherever it happens to have been dropped by the last wind of which it was the plaything and immediately begins to put out all around it small shoots, which in turn become cacti, exactly like the parent plant.

These young growths increase in size rapidly, sucking the moisture both from the parent plant and from the surrounding earth. The roots do not penetrate the soil deeply, but spread often over a circle whose radius is not less than

ten feet. These roots, too, are small, but practically innumerable, and they get every bit of moisture and plant food to be had in the territory they cover.

When the damp season is over these roots shrivel up and finally fall off, the parent cactus, in the meantime, having been entirely destroyed by the sapping of the young plants. The first wind then picks up these plants and rolling and tumbling them about like bowling balls carries them far over the desert.

Each one of these young plants, in its turn, settles down at the coming of the next rainy season and reproduces its kind in a circle around itself, only to die as its parent died.

In cases of the rootless cactus brought to the fertile lands of the California coast and set out where they are given plenty of water a peculiar condition results. The parent plant, dying from the constant sapping of the circle of young ones around it, leaves this circle a hedge of thorns. In turn each one of these dies, leaving the outer segment of a still larger circle, inasmuch as the seed dropped or the rootlets put out will not take hold in the inside of the circle where the life of the parent plant has made the earth sterile.

The result of this is that since the plants in such conditions keep on growing all the year round, the single cactus soon becomes a ringed hedge all round the territory in which it was first set out. Such rings in sheltered parts of the desert where the ground was a bit less dry have resulted in endless speculation by botanists until the true reason was discovered by the bringing of a few of the plants to the coast experiment stations by travelers who had crossed these deserts."

The photograph accompanying this unique sketch represents a bunch of the fruits of the unicorn plant (*Martynia*) and the reckless disregard of truth displayed by the author excites admiration. The actual history of these fruits, their formation, structure, ripening, and transportation by

animals, the important part played by the fiber derived from them in the textile work of the Indian, as well as other features, furnish facts which for novelty and interest far surpass the efforts of Mr. Dunn's imagination.

MINOR NOTES AND NEWS.

Professor C. R. Barnes and *Dr. J. G. Laud* of the University of Chicago have started on a tour of Southern Mexico for the purpose of making collections and investigations of the bryophytes. The Colima region on the west coast, the slopes and lowlands south of Orizaba and the isthmus of Tehuantepec will be visited. Photographic equipment of unusual excellence has been provided for the work of recording habits and habitats.

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THE COURSE OF THE VEGETATIVE SEASONS IN SOUTHERN ARIZONA.

By D. T. MACDOUGAL.

CLIMATIC AND VEGETATIVE CONDITIONS.

The climatic and physiographic features which characterize deserts comprise combinations of meteoric and orographic factors which produce a rainfall markedly less than the possible evaporation, low relative humidity, comparatively small vertical increase in soil moisture, low humus content of the soil, undeveloped drainage and comparatively great diurnal variations in both soil and air temperatures. Many of the plants and animals of such regions exhibit distinctive habits and specialized structures, but it is not to be taken for granted that all of the organisms native or resident within a region properly designated as a desert, show marked xerophilous qualities. On the contrary it is quite possible that species suitable by form and structure for existence under conditions furnished by regions of great precipitation, may find wide distribution in arid areas. This occurs, however, only when the scanty precipitation comes within a limited part of the year giving rainy seasons or periods of maximum precipitation, in which such forms may carry out their entire cycle of activity and then pass into dormancy, remaining quiescent in the form of seeds or modified shoots during the intervening drier seasons.

The region considered in the present paper is one which has probably had an arid climate since Pleistocene times, and a large number of the plants now inhabiting it must have originated within its limits. In the progressive desiccation of this or any other region the forms present would necessarily restrict their activity to the periods of greatest precipitation in the manner described above. Later, by some method of evolutionary development, species capable of carrying on growth and other activity during the drier periods must have arisen, and it is these which characterize the desert. A consideration of all available data leads to the conclusion that all xerophilous or desert species have originated within comparatively recent time.

The newly originated xerophilous forms and the moisture requiring species may live intermingled over the greater area of any desert. In the desiccation which has resulted in the formation of a desert, however, there are general included topographical features, such as mountain ranges, in which the special conditions favorable to condensation, and the lowered temperature due to elevation may combine to furnish suitable habitats for moisture loving species with more or less alpine characteristics. Thus included within the sub-tropical Arizona deserts which have an annual precipitation of 10 to 12 inches are many of these elevated mesophytic islands receiving 30 to 40 inches of rainfall annually, and which sustain a vegetation including many forms of the temperate or even arctic zone.

These generalizations are clearly illustrated by the facts to be obtained by an analysis of the flora of the Tucson region, where two maxima of rainfall occur, one in mid-winter and the other in mid-summer.

THE WINTER WET SEASON.

The secondary maximum of precipitation is in December and January, and amounts to 2 to 3 inches during these two months. On the higher levels this comes in the form of snow, and generally melts slowly in the glare of the noonday sun

RAINFALL
DESERT LABORATORY
1906
By months, in inches
(Total 11.10 in.)

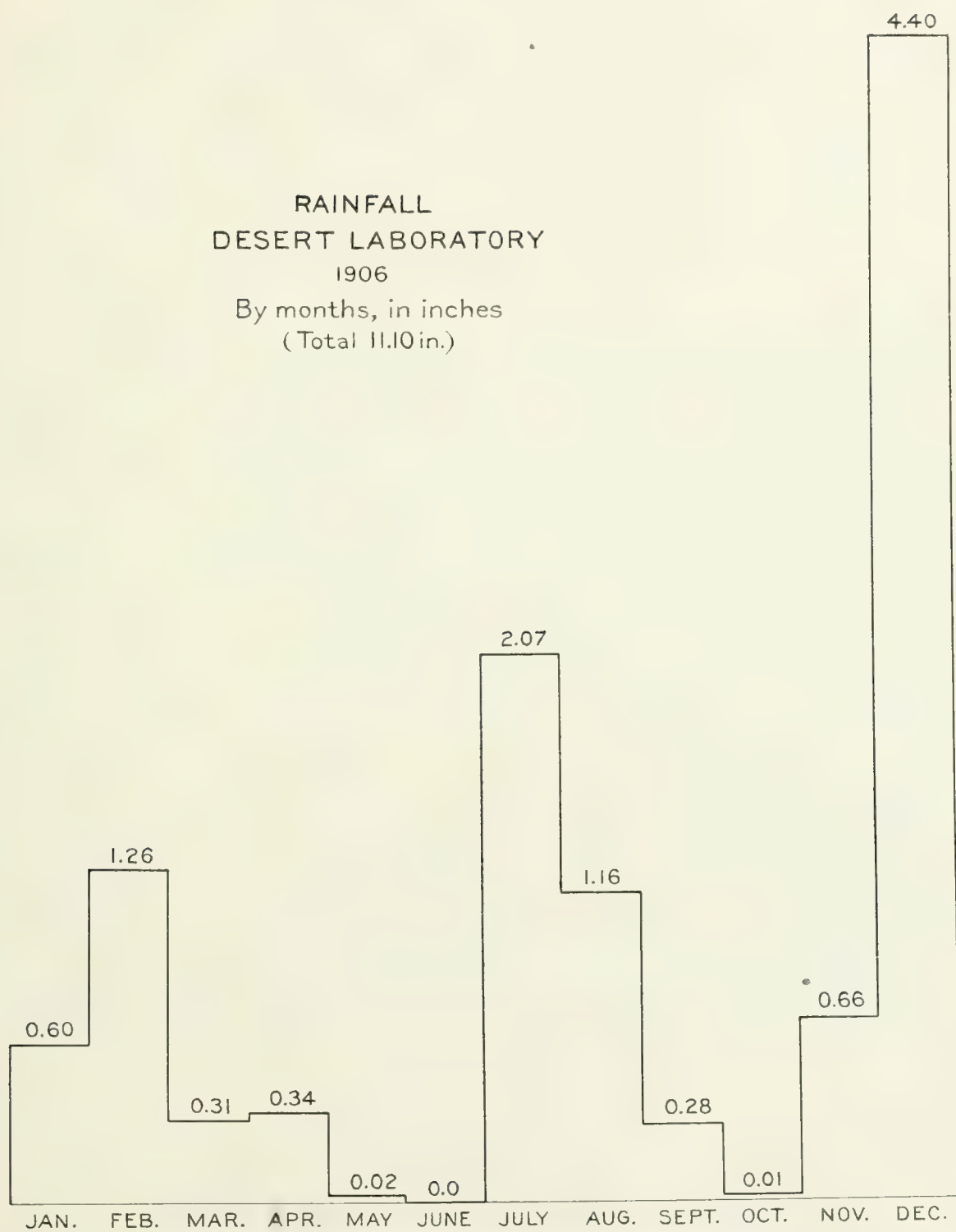


Fig. 1.—Curve showing seasonal distribution of rainfall at Tucson, Arizona, in 1906.

and is almost entirely absorbed by the soil, thus yielding the greatest efficiency in promoting the growth of plants. At levels between 2,000 and 3,000 feet the summation of temperature effects following the northward movement of the sun after the winter solstice soon begins to show, many forms awakening to marked activity in January; a large number bloom in early February, maturing fruit in March and April with the diminution of the rainfall. In all of this *winter wet season*, as it may be termed, a checking action is exerted by the low night temperatures, which drop to 30° and even 20° F. on many occasions; a few warm days bring a luxuriant crop of low herbaceous annuals almost to bloom, which may then be blighted by the frost in January, and in the general average of conditions it rarely occurs that the more precocious forms open flowers before the first week in February.

It has been found by the author that the feature of temperature upon which the progress in development of a plant rests is not the average temperature, but is the amount of heat exposure, calculated by applying the number of hours the temperature has run above the freezing point to the height of the thermometer above this critical point. The starting point of such calculations may begin at the winter solstice or, in the case of specially preserved seeds, at the time of sowing. It seems especially applicable to begin with the winter solstice in the case of the plants active in this season, since they begin to show signs of awakening within a very few days after the sun has begun to move northward. (This method was fully described in the PLANT WORLD for October, 1907.)

The thermal constant for insects, as a practical conception has been worked out independently by Prof. E. D. Sanderson, who uses a method parallel to that previously described by the author. (See Sanderson, E. D. The relation of temperature to the hibernation of insects. Jour. of Economic Entomology. 1:57. 1908.)

The records at the Desert Laboratory show that the *Anemone* of this region and the few early blooming species that appear with it as described below, require about a thousand hours exposure to temperatures above the freezing point to enable them to open flowers receiving in this time (in 1907) 21514 hour-degree-Fahrenheit units of heat exposure. During this time the thermometer may drop below freezing

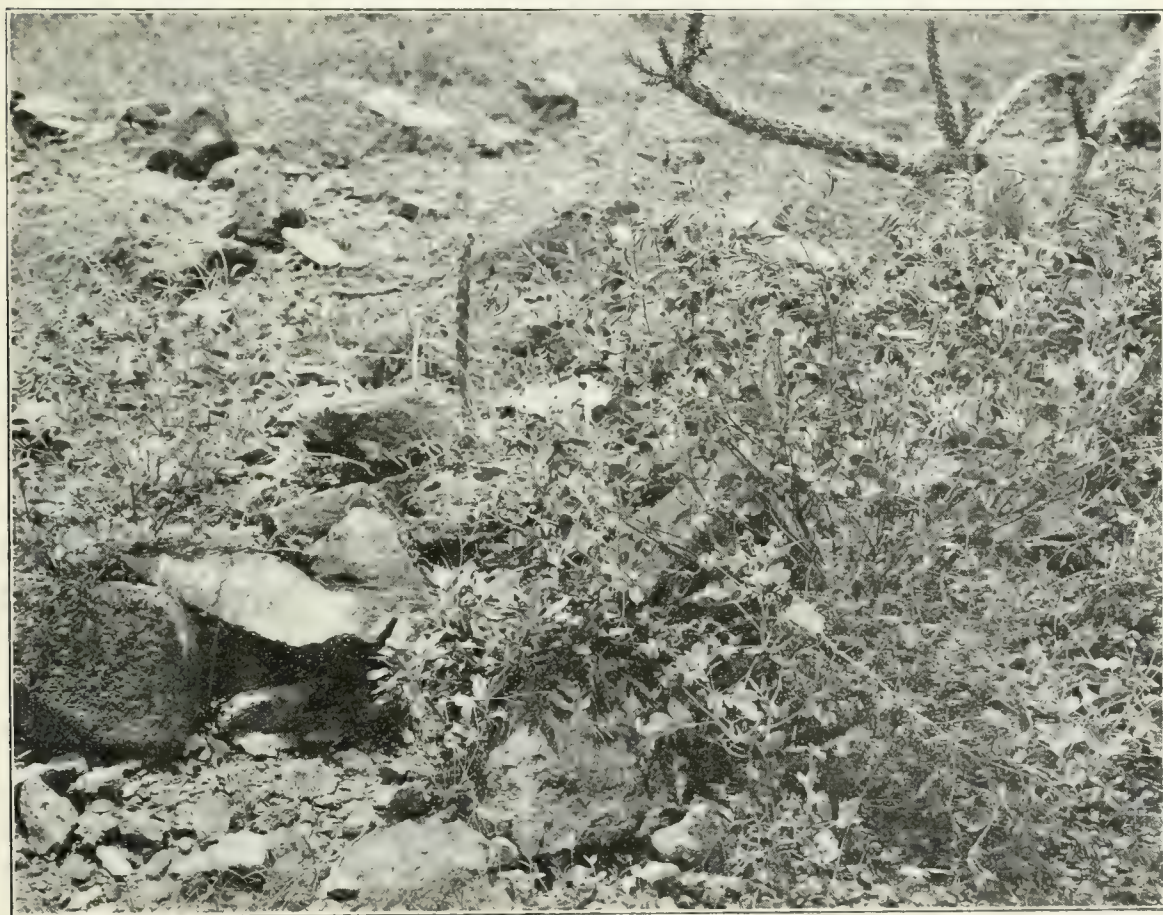


Fig. 2.—*Cassia covesii* on Tumamoc Hill.

point for a total amount of 8 to 10 hours. It is interesting to note in this connection that *Draba verna* one of the earliest spring flowering plants of New York opened flowers after 974 hours exposure to temperatures above freezing point, receiving in that time 4110 hour-degree-Fahrenheit units of heat (originally calculated in hour-degree centigrade, but transposed here for comparison), and being subject to a much larger number of hours exposure to freezing tempera-

tures. The sugar maple in New York requires 1100 hours exposure to temperatures above the freezing point, receiving in that time 7772 hour-degree-Fahrenheit units and being subject to temperatures below freezing point for a number of hours the total of which is approximately equal to that above. The earlier plants of the sub-tropical desert about Tucson are therefore seen to require nearly three times as much heat as the vernal forms of the temperate zone for the maturity of the reproductive organs. The total exposures for the year 1907 as measured at the Desert Laboratory are approximately as follows:

From winter solstice to February 1, 21514 hour-degree-Fahrenheit units; from the winter solstice to the beginning of the dry fore-summer, April 1, 59071 hour-degree-Fahrenheit units; to the beginning of the moist midsummer 160539 units; to the beginning of the dry after-summer, September 1, 236905 units. Total exposure for the year 1907, 325385. Shortly before the winter solstice, the temperature may fall below freezing point for four or five hours, thus making a total of about 12 hours in the year during which plants at the Desert Laboratory may be subject to freezing temperatures.

Winter perennials. A large number of species with perennial root stocks and bulbs push out new shoots, and form leaves and flowers under the influence of the minimum exposure noted above in conjunction with the abundant supply of moisture. Among these may be mentioned the following:

Brodiaea capitata, with a few blue or white flowers borne on a slender scape with a deeply buried bulb; *Anemone sphaenophylla* a relative of the crowfoot, with long-stalked cylindrical fruits; *Penstemon wrightii*, with its crimson funnel-shaped flowers, a succession of which follow through March and April; and *P. parryi*, on the slopes, with a metallic luster to the slender corollas. Stalks of the last two species are a favorite food of rock-squirrels, which cut them off near the base and carry them away to their retreat. Later another

species, *P. palmeri*, comes into bloom higher on the slopes among the oaks, the bases of the opposite leaves being so fully joined together as to be perfoliate. *Hilaria mutica* is a true desert grass which finds a place high up on the slopes, where it makes patches of color visible for miles. *Cassia covesii* opens its yellow flowers and forms its pods early, while



Fig. 3.—*Encelia farinosa*.

Franseria deltoidea, a low shrub, has its bur-like fruits ready to be carried away by any moving thing that touches them early in April. The most striking color of this period, however, is that of the globose clusters of *Encelia farinosa*, nearly a yard in diameter, which are so numerous and so dense on the slopes as to give a golden color that may be caught by the unaided eye for 7 or 8 miles. This plant is to be noted as

having an enormous range since it is to be found on the slopes of the Santa Catalina mountains at 4000 feet, and on suitable exposures, has been seen far to the southward among the Pinacate volcanoes in Sonora nearly down to sea level. The aromatic secretion on the stems mixed with grease or tallow has long been used by the Indians and Mexicans as a salve.

One of the wild tobaccos, *Nicotiana trigonophylla*, perches among piles of rocks or on the edge of escarpments, and its creamy yellow flowers open early in February. A second species is more widely distributed along the washes and lower slopes, and is used for smoking by the Indians of the region. The third representative of the tobaccos is found in *Nicotiana glauca*, native to South America, which has found its way over the western part of the northern continent, being a veritable tree weed, being known to the Mexicans as the San Juan tree. Although coming into bloom in the winter it forms flowers during any part of the year in which it receives sufficient moisture.

Verbena ciliata grows in low clusters, and the individuals in any locality show a range of variation of flower-color from deep pink to pure white, while the flowering season is ended only by the spring drouth. The creosote bush, *Covillea tridentata*, begins to open flowers and make new leaves in February which continues for two or three months. On the mesas and sandy washes the composite *Baileya multiradiata* opens numerous yellow flowers from its clumps of stems, that last with their brilliant yellow effects for many days. Low and decumbent on the hill slopes are the crooked branches of a small shrub, *Calliandra eriophylla*, which forms clusters of flowers of a delicate pink and soon matures its fruits, while a second species of the genus, less inconspicuous, abounds on the lower mesas.

The greater number of these perennials cast away their leaves with the approach of the high temperatures of April and May, and the stems, bulbs or root-stocks, go into quiescent condition from which they do not awaken until the fol-

lowing December or January, eight or nine months later, the period of activity being comprised within a compass of a hundred days. Some, however, like *Covillea*, with varnished leaves, and a few other species with heavy protective coatings of cutin or hairs on the foliar surfaces, retain these organs during a great part of the year, and derive some benefit from the activity of the chlorophyl during the intense insolation of



Fig. 4.—The Creosote bush (*Covillea tridentata*.)

the summer months. While the soil is supplied with water in fair plenty, at least during the early part of this season, yet humidity of the air ranges between 30 and 40 per cent and only plants with protected surfaces may function to advantage in it.

Winter annuals. Of the large number of herbaceous forms which spring from germinating seeds in the wet winter season and soon pass the whole cycle of existence, a few of the

more prominent may be mentioned.

Astragalus nuttallianus, an innocuous relative of the "loco" weed, ripens its curved reddish pods early in March and scatters the seeds in the gravel, the small stems withering away long before the summer comes. *Streptanthus arizonicus*, one of the mustard family, soon reaches the adult stage, with its deep greenish stems and rather lush leaves which show but little indication of belonging to the desert. Two of the borages, *Harpagonella palmeri* and *Pectocarya linearis*, occupy the most prominent place in this group of plants, the soil being generally so thickly sown with their seeds that the rains bring up a dense carpet of these plants; every square inch of available space on Tumamoc Hill is occupied with their short, hairy stems, the burs being quickly matured, and in the dry weeks of April forming an unpleasant feature of a walk off the trail. Plantagos abound: *Plantago spinulosa* stays on the steeper slopes, while *P. ignota* is abundant over vast areas of gravelly or sandy mesa, the silvery, hairy and grayish appearance of the leaves being such that it is difficult to determine at a glance whether the plants are alive or dead. Of the annuals, these two are furnished with the structures most generally characteristic of forms that live in dry places. *Phacelia tanacetifolia*, with its scorpioid inflorescence, is scattered among the rocks and on the slopes over a wide range, and as it does not bloom until well on with the coming dry weather, it and its neighbor, *Amsinckia intermedia*, with yellow flowers, have some of the features of desert plants. Early in April, shining silvery balls of fruit, reminiscent of the dandelion, are met frequently, and these prove to be relatives of that weed, being *Microseris linearifolia*, with erect linear leaves around the scape which bears the fruit, and *Rafinesquia neomexicana* with shorter lacinate leaves on its thicker stems. The wild carrot, *Daucus pusillus*, holds its umbels of inconspicuous flowers but a few inches above the ground, and these ripen seeds in April, when the entire plant quickly dries up. *Bowlesia lobata* is abundant in certain localities, while two gillias,

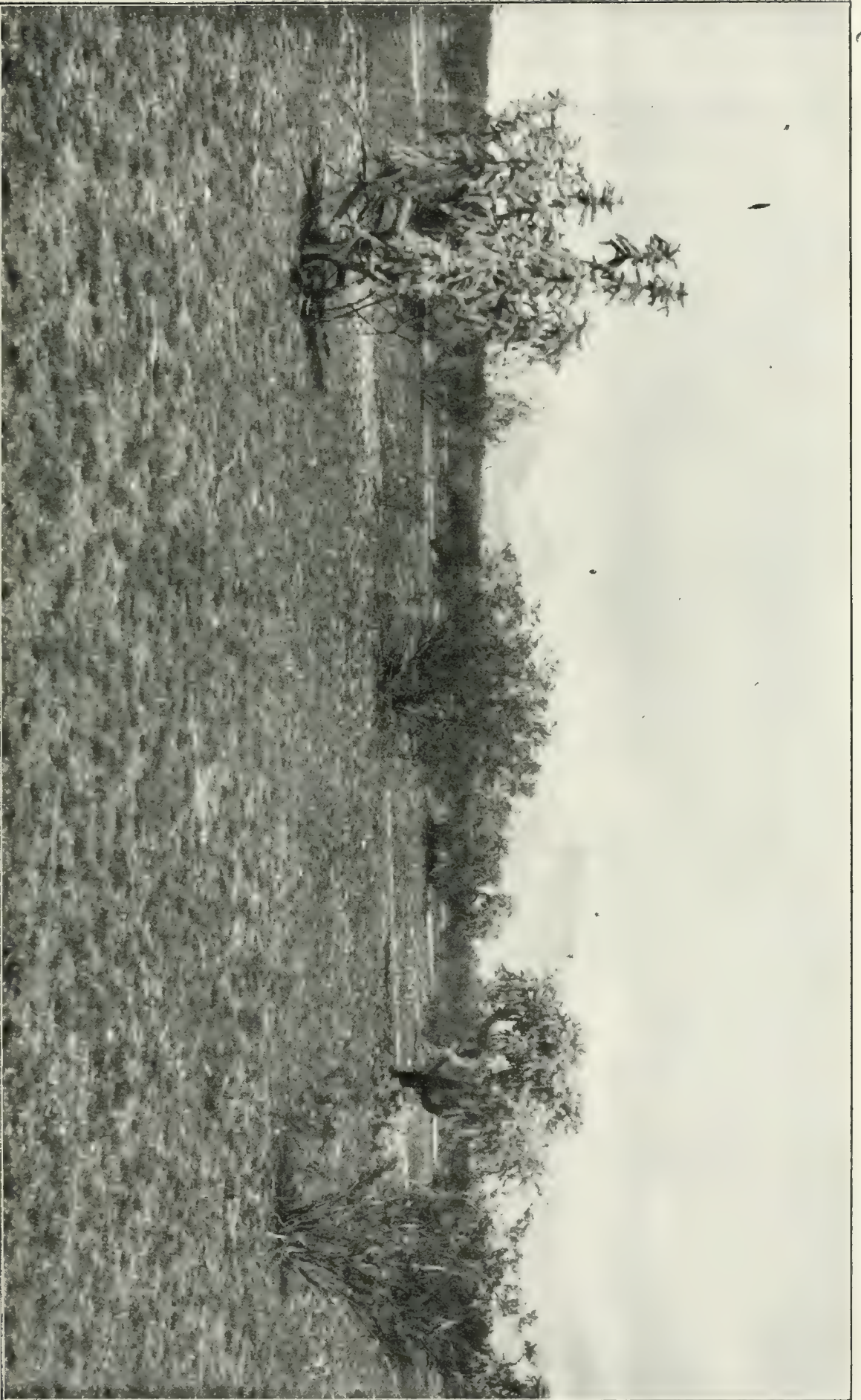


Fig. 5. *Opuntia versicolor* and *O. spinosior* with carpet of *Piantago* in melt ice snow, Tucson, Feb., 1902.

relatives of the phlox of the gardens, are abundant; *Gilia flo-cosa* displays its small star-shaped flowers everywhere on short simple or branched stems, which, with a supply of water, take on some stature and throw out laterals, but which usually send up a single stem with a hairy globose head, from which every day a flower opens that may vary in color from pure white to deep blue. The other species, *G. bigelovii*, stays mostly on the slopes, and its slender, shiny stems are taller than the species described above. Here and there are to be found small compact clusters of flowers like small white daisies borne on short stems, *Eremiastrum bellioides*, which also exhibits the marks of the desert. Finding its way about, across the mesas and over the hill slopes, is the alfilaria, *Erodium cicutarium*, a relative of the geranium, which spreads its flat rosettes of greenish, lacinate leaves wherever it may find a foothold, and after its pinkish flowers come the long fruits, which sow the seeds so abundantly and efficiently that this plant travels by leaps and bounds. Small, straight stems, clothed with hairy, linear leaves, terminate in spikes of delicate purple flowers in *Orthocarpus purpurascens palmeri* and single individuals occur here and there on the mesas, in the sand and gravel, but in some places so densely are they crowded that great purple patches are formed on the slopes. Occasionally an individual is found which has lost entirely the power of making the characteristic color of the flowers, while others lack it only partially, and of these an experimental study has been begun. The Mexican poppy, *Eschscholtzia mexicana*, likewise offers many things of interest. Its flowers are light yellow or have a distinct admixture of red; its petals show entire margins or are deeply cut; the orange eye at the bottom of the corolla cup may be clearly defined and sharp or diffuse; but, most striking of all, a number of individuals have been found by Professor Thornber in which the foliage has a paler color than ordinary and the flowers are of a clear, creamy white, the eye at the bottom being the only color retained, and at the same time the margins of the petals are

delicately frilled, making a most striking deviation from the main type, between which numerous intermediates are to be found.

The more prominent structures by which these annuals are fitted for life in the desert are not to be looked for in the shoots or leaves, but in the seeds and their powers of endurance. Seeds are ripened and thrown on the ground in March and April. The surface layers of the soil reach a temperature of over 100° F. during the summer months, the rains come and soak both the soil and seeds, but still no activity is shown, and the experimentalist who attempts to use these plants during the summer will find that he might as well have sown so many pebbles in his pans. The summer cools into the autumn, and cooler nights come, followed by the winter rains of December; then and not until then, do these refractory seeds begin to show signs of life. Two features are possibly involved in this delayed germination. One is that the seeds need a certain length of time for the carrying out of slow changes toward maturity, which take place during the so-called resting season and which require a period of determinate length not to be shortened. Secondly, it is quite possible that in some species the baking summer heats, the moist soil, the cool nights of autumn, and the rains are a series of stimuli which must follow each other in turn and act for a length of time before the seedling emerges from its protecting coats. Favor is lent to this view by the fact that in some species germination may be induced earlier by simulating the summer heats and the winter coolness by the use of the oven and the refrigerator.

METHODS OF VEGETATIVE REPRODUCTION IN GUAYULE AND MARIOLA.

BY FRANCIS E. LLOYD.

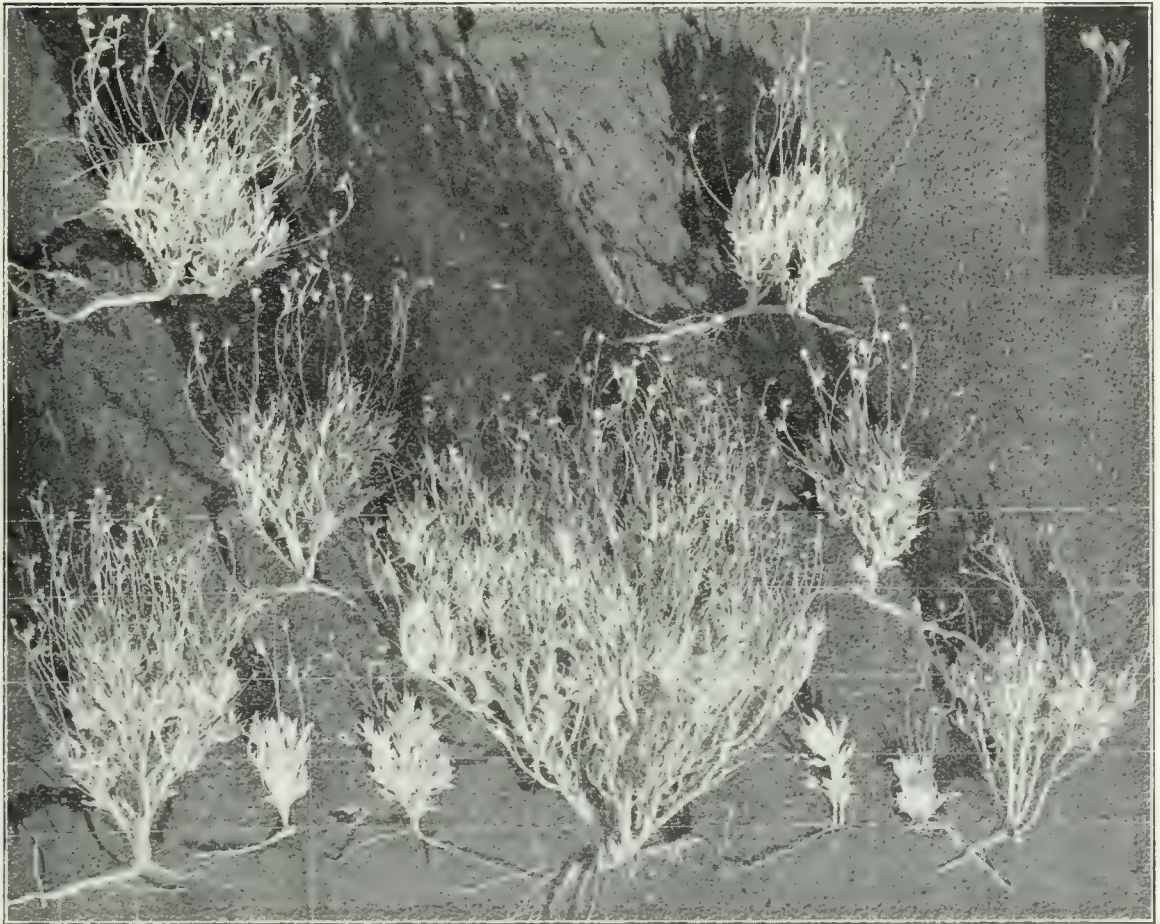
Guayule (*Parthenium argentatum* Gray) and mariola (*P. incanum* H. B. K.) are two closely related shrubby species of the genus *Parthenium*, both occupying similar habitats though in varying ratios in the desert regions of the *mesa*

central of Mexico, and extending their range into southwestern Texas. Both plants have of recent years been brought into economic prominence by virtue of the fact that they secrete rubber, guayule being the more important plant in this regard, since the amount of the substance sought for in commerce is much too small in mariola to make it worth while to exploit it. The two illustrations which are presented will serve at once to contrast these interesting plants. It may be added by way of orientation that they are members of the Compositæ, but are peculiar in having only five ray-flowers in the head, these only being capable of producing seed. The disc flowers are all staminate, but the style grows after the usual fashion in the Compositæ, serving to eject the pollen. Reproduction takes place readily and very generally by means of seed, though the contrary has been intimated,* but these two species have marked methods of vegetative reproduction which complement the method by seed, and are further of interest in that they are not common to the two species. It would be quite useless to speculate how this condition has come about, so that we shall turn directly to the facts. They are especially worth recording not only because they have never been studied with care and indeed have been entirely overlooked by those who have essayed to study the plants hitherto, but because of a curious bearing on the problem of grafting between the two species in question, a suggestion which has been made, but to my knowledge never carried out.

Turning first to guayule we note that this plant regularly produces new individuals by sending up new shoots ("*reton-yos*") from the roots, recalling the behavior in orchard trees, but more definitely adjusted to reproduction than is usual I believe. The root system of the guayule consists of a tap root, a great many short laterals running in all directions, and upward of a dozen very long secondary roots placed at a slight depth in the soil, and of small calibre, 5 mm. or often

*Ross, H., Der Anatomische Bau der Mexikanischen Kautschukpflanze "*Guayule*," Ber. d. Bot. Gesellsch., 26a: 248-263, Ap. 1908.

less, reaching out to cover a circle of two meters' radius. From these arise the new shoots, removed from the parent plant often more than a meter, and in many instances so resembling seedlings in habit that it is only by removing them that their true origin may be determined. More frequently, however, two to several retonyos arise at one point, when their nature



D E
F G
B K H A I L C

Fig. 6.—Retonyos of guayule (*Parthenium argentatum* Gray.) A About nine years old. B. Retonyo which has developed after the manner of a seedling, and of slow growth, 8 years. C and D, 4 years. In both these the proximal portion of the root has already disappeared. E and F, 3 years. G, 4 years. H and I, 2 years. K and L, two to four months. At the upper right hand a small seedling is introduced to show the contrast of root system.

may be guessed at by the several closely placed main stems, or by the line of apparently independent plants. These differences are shown in the photograph.

The formation of these new plants in this manner is not spasmodic or exceptional, nor are they fugitive in their nature. Under certain conditions they are produced in such numbers as to entirely overshadow the number of seedlings; and they as frequently grow into maturity, producing a plant which, if the origin were not known, would not unlikely be considered a varietal type, in point of habit. The mature plant which had its origin as a seedling, has a single trunk, usually ten or more, sometimes 20-30 centimeters in length; the mature plant produced vegetatively has a very short trunk, or a group of separate ones more or less coalesced by growth. The character of the root system is even more distinct. In the seedling, the tap root may at once be distinguished, while in the form of root origin there is no tap root. After the new shoot has appeared, the portion of the mother root lying between it and the parent plant retains its small calibre, and finally dies away from the new growth. The distal portion, however, becomes functionally a tap root, but with its axis at first nearly at right angles to the axis of the new shoot. This position is maintained in spite of secondary changes, and enables one to recognize an individual of root origin even at maturity. Very occasionally adventitious roots arise from the basal portion of the new stem, thus adding later elements to the system which may more or less obscure the condition described, and this furnishes a rare exception to the general rule that the guayule is unable to produce roots from the stem.

The ratio of the number of new plants arising as seedlings and of those arising as root-shoots varies with the habitat. Both forms may be found in any situation, but the retonyos are much more numerous on stony slopes, often very much outnumbering seedlings. The reverse relation is seen in more level places. Thus, at the foot of a low ridge, I have found as many as thirty small seedlings in a square foot, and larger ones scattered about relatively thickly. A zone of this character could be traced along the ridge. Just above this zone, another could be made out in which the retonyos were

abundant, and the seedlings scarce, while coming to the top of the ridge, seedlings again outnumbered the retonyos. Thus on that part of the slope most affected by erosion and where there is more chance of uncovering the shallow lying roots, the retonyos are most abundant. It would appear therefore that exposure to light is a potent if not the most important factor in inducing budding in the roots. Yet I have found that when a plant is removed by cutting at the base so as to sever the roots and leave them in the ground, retonyos start not only where the root is accidentally exposed, but as far back as the drying out of the root makes it necessary. A root thus severed in January failed to bud till June in consequence of the lack of rain; when it at last did rain, the buds started out 12 cm. away from the cut end, and several cm. deep in the soil. On the other hand, roots purposely exposed for a portion of their length failed to start buds for six months, when last examined. So that the case appears to be more complicated than at first appears. Injury may be a factor at times, but experimentally I have shown that scarring or cutting the cortex is not sufficient to ensure budding.

This occurrence of retonyos in guayule presents a very interesting problem biologically. In a habitat where the rainfall is very meagre, and where years occur in which the condition for germination are prohibitive; and where moreover the sudden and severe rains wash the soil on the steeper slopes severely enough to remove seeds or expose seedlings when young so as to prevent their further growth, it will easily be seen that the vegetative method of reproduction presents certain very marked advantages. This is true also where the soil is confined to the crevices of the native rock where this lies at or very near the surface. This condition occurs very frequently in Northern Zacatecas, Mexico, where large areas will be seen in which the vegetation is confined to zones of outcrop, occupying the soil beneath the edge of a stratum. Where the relation of the strata to the surface in position is such that flat blocks of rock support a thin layer

only of soil, the distribution of vegetation is determined by the fissures. In the case of guayule we have an exception, for this plant may send out a shallow lateral root over a block of stone, and shoots may start above it. Very frequently we find plants which have grown in this position, with their roots straddling the subimposed rock. Such are almost invariably retonyos. Plant A in the figure was found so placed. There are plants which can compete with the guayule in this regard. Such an one is the lechuguilla (*Agave lecheguilla* Torr.) which spreads out by means of stolons, and occupies areas for itself to the exclusion of everything else. Nevertheless, it is clear that the habit described is of no small importance in the fight for foothold. One can easily imagine too, that a distinct advantage is to be had by the rate of growth and quickness with which the ability to flower is reached by retonyos. The rate of growth is a function of the size of the mother root; but it is a very common thing for a retonyo to grow 10 cm. and to come into flower in two months in summer (K and L in the figure). Seedlings on the other hand scarcely ever flower before the third year, and the amount of growth then does not more than equal that of a single stemmed retonyo. At the end of three years the retonyo makes a respectable plant (F in the figure) and flowers abundantly. The influence, therefore, which retonyos would have in reforesting processes, both by their own growth and by seeding, can be well appreciated, and probably with difficulty overestimated. Some basis for judgment in this regard will reward a study of the accompanying photograph.

The case of mariola is somewhat different. In the first place, the root-system is different in that the laterals run at a steeper angle into the soil. Retonyos are formed occasionally, but as far as my observation goes, always close to the plant, within say 5 cm. What, however, always happens is this: From the basal portion of the stem where there are many dormant buds, as a sequence of the short internodes

marking the slow initial growth of the seedling, new slender shoots arise, growing to a height of 30 cm., more or less, in two months. From the base of each such shoot an adventitious root starts out at the base, immediately above the point of origin of the shoot. This usually single root develops as

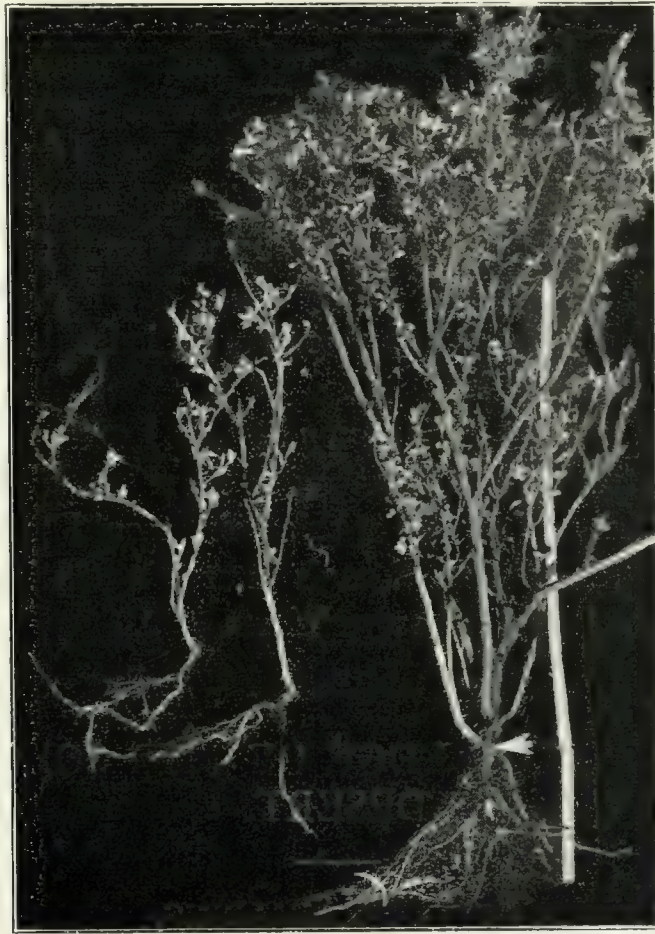


Fig. 7. A mariola plant (*Parthenium incanum* H. B. K.). The arrow point indicates the point of insertion of the right hand branch, marked with a white band. The corresponding root is also marked. At the left are two detached shoots each with its separate root system.

a tap root, and supplies all the water for the daughter shoot, which develops apace, and becomes ultimately an independent plant. The isthmus of tissue between it and the parent plant does not enlarge much in any case, so that it is quite easy, on taking up a bush of mariola, to separate it into several smaller plants, by merely breaking off the independent elements. Thus the habit of mariola and guayule in this regard

is so different that the former plant remains a single-stemmed shrub of tree like habit, while the mariola has a bushy habit. This marked difference, it will be seen, precludes the advisability, though the possibility might remain, of grafting the guayule on the mariola, a suggestion which has been made on the assumption that increased growth might follow in the scion. No economic result would follow and for this reason. Supposing that we graft successfully a piece of guayule on a stock of mariola. The scion grows, but at the same time new shoots arise from the base of the stock as described, and their growth is so rapid that in a month or two the guayule shoot is overtopped and this ends the usefulness of the graft for economic purposes. We might very well make a graft for the purposes of pure science, but economically it would be a failure.

An important question may be asked with regard to the relative importance of the habits in these two plants in competition, but any discussion at this point would be little better than speculation, which, though interesting in itself would, I fear, lead us beyond observed facts.

THE WESTERN EDGE OF THE COLORADO DESERT.

By V. M. SPALDING.

The great desert region of the southwestern United States, which travellers by the Southern Pacific Railroad remember as a weary stretch from central Texas to the mountains of California, though possessing certain general features characteristic of arid or semi-arid regions the world over, nevertheless exhibits a great variety of climate, soil, and topography, with a corresponding variety of plant life. In the extreme western part of this area, in which the Salton Basin is located, and which is commonly designated as the

Colorado Desert, the scanty rainfall of only two or three inches a year, the intense heat, and low percentage of atmospheric humidity have so intensified desert conditions that the vegetation is meagre in the extreme, and wide areas previous to their overflow by the Salton Sea were either completely bare, or produced only here and there a solitary salt bush or some other extreme type of xerophytes. Toward its outer limits, however, the vegetation is more abundant and varied.

This division of the desert is sharply bounded on the west by San Jacinto Mountain, which rises to an altitude of 10,805 ft., and the broken ranges and peaks which, farther to the southward, include the Cuyamaca Mountains, barely attaining a height of 6,500 ft., and some lesser elevations. The abruptness of the change from the scanty vegetation of the desert to mountain chaparral and forest can hardly be realized except by actually going over the ground, and there are perhaps few places where the transition from one to the other can be more satisfactorily studied.

The approach is best made from the west. A convenient starting-point may be made at the small mining town of Julian, at an elevation of slightly upwards of four thousand feet above sea level. On a favorable day, standing on a ridge above the town, one can see, fifty miles away to the west, the Pacific ocean and, nearer on the east, the Salton sea, often beautifully clear, and, with the dim outlines of the mountains beyond, presenting a picture not soon forgotten. At closer range, for a few miles to the westward, the eye takes in a region of rugged physical features, an irregular congeries of ridges and peaks, with picturesque canyons between, characterized, first of all, by the presence of numerous live oaks (*Quercus agrifolia*), by wide stretches of grass land, now covered chiefly by wild oats (*Avena fatua*), and lastly by a chaparral which covers the rocky hillsides with a thick growth of *Adenostoma*, *Ceanothus*, *Cercocarpus*, scrub oak and manzanita, with other less characteristic shrubs.

In the immediate neighborhood of Julian the California black oak has, to a great extent, replaced the live oak, and on the hill sides pine trees (*Pinus Coulteri*) of considerable size occur, either scattered or occupying areas of greater or less size, in the midst of the grass-covered slopes, while the chaparral, though still of frequent occurrence, has become a subordinate feature. The town and adjacent country for some little distance around is well within the pine belt. The average annual rainfall from 1900 to 1906, as reported by the local observer, was thirty inches, and as a farther indication of climatic conditions, it may be said that this region is celebrated for the abundance and excellence of its apples, pears, plums and various other fruits.

The picture will be more complete and the contrast more impressive if, before making the sharp descent into the desert, we take the mountain road from Julian to the Cuyamacas, a few miles to the south, and there ascend to the summit of one of the three peaks. Taking for convenience the middle peak, and beginning at the reservoir at an altitude of 4,500 ft., the yellow pine (*Pinus ponderosa*) and the black oak (*Quercus californica*) are characteristic tree species, and between 4,500 and 5,000 ft., the incense cedar (*Libocedrus decurrens*), the sugar pine (*Pinus Lambertiana*), and white fir (*Abies concolor*) come in, becoming dominant before the summit is reached, at an elevation of 5,900 ft., making a fine forest of heavy trees, in the low undergrowth of which are seen *Pteris*, *Rubus*, *Thalictrum* and *Symphoricarpus*, gooseberry, rose bushes, choke cherry, and other reminders of northern forests. From the summit of the peak the superb view is most perfect, and, with what has already been seen at lower points, gives a clear impression of the successive zones of vegetation. Around the observer is the coniferous forest just described; below it is the narrow zone of Coulter's pine and black oak; and beyond this stretching away many miles to the vicinity of the Pacific, is a billowy confusion of mountains, plains, and valleys, the broad belt of the chaparral and live oak. To the

east, the Salton Sea, in full view, lies in the midst of a desert that abuts upon the mountains so sharply that they seem like a boundary wall. On this side, to be sure, as on the other, the forest still occupies the peaks, but the chaparral zone below has been narrowed to a width of perhaps six miles, in contrast with the forty miles or more which it occupies on the seaward slope, and it is succeeded, as far as appears from this view point, almost with the sharpness of a surveyor's line, by the brown hillsides and the low and scanty vegetation of the desert.

Taking now the way eastward toward the desert, where the Imperial road begins to descend from Julian to Banner, the abrupt change in the landscape is so striking that it can hardly fail to attract the attention of the most casual observer. Behind are the open grassy fields with their fine growth of pines, oaks, and manzanita, but as we advance to the eastward the pines and oaks cease at once, except for a few small individuals, the manzanita becomes dwarfed, reaching hardly a meter in height, and takes its place as one of the constituents of a dense chaparral in which scrub oak (*Quercus dumosa*), chamisal (*Adenostoma fasciculatum*), and several species of *Ceanothus* are conspicuous.

The road follows the right side of a deep canyon, descending 1,500 ft. in the first five miles of its course. The steep side of the canyon along which the road winds has a northerly exposure and is close enough to the opposite side to admit of observation of the influence of aspect on vegetation at this point. The density and variety of the chaparral on this northern slope is noticeable. In a leisurely walk there were found species of *Heteromeles*, *Cercocarpus*, *Lonicera*, *Cercis*, *Clematis*, *Erigeron*, *Berberis*, *Rhus*, *Pentstemon*, *Prunus*, *Artemisia*, *Dendromecon*, *Chrysoma*, *Rhamnus*, *Sambucus*, *Adenostoma*, and even a *Nephrodium*, and in hollows or arroyos willows and cottonwoods with well developed black and canyon oaks. On the left side, facing the south, only a few rods away, the chaparral is lower and far less

dense and it exhibits far less variety, being composed in great part of *Adenostoma*, with scattering yuccas (*Y. Whipplei*), white sage in spots, and occasional individuals of scrub oak and manzanita.

The close proximity of the two sides of the canyon, each with about the same gradient, leaves little room for doubt that difference of aspect is the occasion of the wide difference of vegetation that has been noted. It must be that on the left side, with its southern exposure, conditions prevail that even at this altitude approach in some measure the severity of those of the desert, and that the great majority of the plants which occur in the chaparral of the right side are quite incapable of growth on the left, except in favored spots.

In the neighborhood of Banner, between five and six miles below Julian, at about 2,500 ft. altitude, there are indications that "the edge of the desert" is close at hand. We now come upon scattering individuals of several desert species, the mesquite and catclaw (*Acacia Greggii*), a flat opuntia, like *O. Engelmanni*, one of the branching opuntias, and in lower ground the desert willow (*Chilopsis insignis*).

Following the road eastward for the next three miles, as it very gradually descends, it is noticeable that the live oaks have dropped out and but very few species of the chaparral are to be seen. *Adenostoma* still occurs, and there are occasional specimens of scrub oak and a few other shrubs, but with them, forming in places a remarkably mixed association, are species of *Agave*, *Yucca*, *Krameria*, *Opuntia*, *Cereus*, and *Atriplex*. The presence of a Juniper and a plum add to the confused mixture of biological forms. Here on the one hand are a few species belonging distinctively to the chaparral of the mountain slopes, but mingled with them are a larger number of true desert plants.

Another mile and the last vestige of mountain vegetation has disappeared. The creosote bush and guietta grass (*Ephedra*) have put in an appearance, the scrub oak and chamisal have fallen out, and the dominant vegetation con-

sists of mesquite, catclaw, *Larrea*, and *Atriplex*, in as true a piece of desert as can be imagined. Thus within a distance of five miles we have passed consecutively through, first, the mountain chaparral, next, a mixture of chaparral and desert forms, and lastly, into a true desert vegetation.

A more perfect knowledge of physical conditions that have resulted in the remarkable differences of vegetation within such short distances is greatly to be desired, though it is not likely that this would furnish a complete explanation of all the facts. At present it can only be said that precipitation diminishes very rapidly from the mountain to the desert, that the air here is much drier, the temperature higher, and the hot, dry winds from the desert induce an especially high rate of evaporation.

It becomes, then, for plants from outside its borders, a test of endurance, and one of the most significant facts impressed on the attention in making the short journey of five miles from the mountain to the desert is that the great majority of the species constituting the chaparral have dropped out by the time that less than a dozen characteristically desert species have come in. Only the chamisal and a few of its associates are capable of enduring the conditions that exist on the edge of the desert, and even these fail to maintain themselves beyond the point where the creosote bush and the guietta grass appear.

There is, in this case, every indication that the species which drop out as the desert is entered are prevented by adverse physical conditions from advancing farther, rather than by competition on the part of the desert species which meet them here. Desert plants are notoriously poor fighters where the conditions are favorable to mesophytes, and, while it is by no means to be inferred that competition does not exist among themselves, it does not appear that it is their presence that prevents the advance of other plants upon their ground. The latter are simply unable to cope with the conditions under which desert plants make a normal development.

But it is not so plain that competition is inoperative in the prompt check at the limits of the chaparral, which the desert species receive in their advance towards the mountains, in fact the well known habits of such a true child of the desert as the creosote bush preclude the supposition that it is prevented from advancing up the slopes beyond its present limits by physical conditions unfavorable to its growth. It is a plant which grows well up to at least 6,000 ft., and thrives in much moister situations than the slopes which it here fails to ascend, so that its failure to find a foot-hold here seems hardly explainable in any other way than that it is quite unable to engage in a successful competition for a place on their own ground with the constituents of the chaparral.

If the explanation here suggested proves to be correct, we are confronted by a situation which indicates that instrumentation, however indispensable in the investigation of ecological problems, is quite inadequate by itself, to ensure their successful solution. It seems plain that plants of the mountain sides fail to extend into the desert because the conditions there are unfavorable to their growth, and these conditions are such as can be determined readily by thermometers, hygrometers, and other instruments; but, on the other hand, some at least of the plants of the desert are not prevented from advancing up the mountain side by any such unfavorable physical conditions, in fact both soil and atmospheric conditions are highly favorable for their growth. Their failure to occupy the ground is apparently due to the simple fact that it is already held by other plants better adapted to the mountain sides which prevent their getting a foothold here. In this case no apparatus, however elaborate, and no instrumentation, however painstaking, can take the place of well directed observation and experiment. The case is instructive in its bearing upon the relations of desert plants to other vegetation, and the evidence it furnishes that on the edge of the desert two very different biological groups

of plants are prevented from advancing into each other's domain by reason of two entirely different causes, the inability of the one group to cope with unfavorable physical conditions, and the equally pronounced incapacity of the other to meet and overcome an adverse living environment.

The Origin of a Land Flora, by Professor F. O. Bower, published by MacMillan and Company.

Prof. Bower's work on the Origin of a Land Flora, which is an elaborate presentation of the strobilar hypothesis, will find a cordial welcome at the hands of all botanists and biologists. Perhaps no more important, certainly no more interesting work has appeared on the subject of plant relationships. Whatever preconceived ideas the reader may have regarding the strobilar hypothesis when he picks up the book he is very likely to become its devoted adherent before he lays it down. The book is so large, it numbers 727 pages, and so important that it merits a critical review, but as it also is many-sided it occurs to the writer that one phase, namely, the value to the teacher of plant morphology, may well be touched on in this place with no pretense of presenting an adequate review. In brief, the value to the teacher of the strobilar theory, as given by Bower, will lie very largely in the unification which it will bring,—it will be found to be the red thread which will bind together apparently isolated facts and make them logical, more easily presented and more readily comprehended.

The first portion of the work treats specifically of the origin of the sporophyte as being especially adapted to the terrestrial habit. Plants with the alternating phases strongly marked, the Archegoniatae, are amphibious, those with sporophyte the predominating phase are wholly land forms, but many still carry evidences of an earlier water habit in certain gametophytic peculiarities, plants in which the sporophyte, the asexual generation, has not appeared, are wholly aquatic.

To trace the origin, development and differentiation of the sporophyte is, therefore, to investigate the origin of a land flora.

The strobilar hypothesis begins with a primitive aquatic form in which there are post-sexual cell divisions which lead to the multiplication of germs. It is upon these germs, accompanying alternating drying and wetting of the habitat, that selection and variation play. Thus the biological conditions attending the transition from water to land naturally encourage some form of "amphibious alternation." Where alternation of generations occurred, therefore, the sexual or asexual phase, became intercalated in the course of the descent of successive gametophytes. Once the asexual phase is formed its differentiation takes place through progressive sterilization, the segregation of spores into pockets, and the origin of appendicular organs. This progression is associated with a need of a larger number of spores, or with their protection, or their nutrition, but the production of spores remains the most complex plant forms, as it is in the primitive sporophytes, the most important function.

"A prototype, which was probably a prevalent, though perhaps not a general one for the Pteridophytes, may then be sketched as an upright, radial, strobiloid structure, consisting of a predominant axis, showing continual apical growth, and bearing relatively small and simple appendages." From this primitive type the author evolves the more complex types of sporophytes by natural process as suggested above and, by extensive reference to anatomical and embryological works, as well as to researches in palæontology, places his hypothesis on what appears to be safe ground. It is this wide reference to other branches of the science that serves to bring into harmonious relation, and give especial point to widely separated facts and to place these together as a logical hypothesis, as presented in so masterly a manner by its author.—W. A. C.

THE PLANT WORLD

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THE COURSE OF THE VEGETATIVE SEASONS IN SOUTHERN ARIZONA.

(Continued)

By. D. T. MACDOUGAL.

THE ARID FORE-SUMMER.

The precipitation shows a decrease to an average of .90 of an inch during February, and this with a further diminution to .77 of an inch during March coupled with the steadily rising temperature brings to an end the activities of the lush and luxuriant vegetation of the moist winter season. The ensuing dry fore-summer may be taken to include April, May and June with a total average precipitation of .67 of an inch, while maximum temperatures, as high as 95-112° F. are presented. The possible evaporation of course exceeds the rainfall by a large ratio, and the proportion of soil moisture as well as relative humidity decreases, the latter sometimes falling as low as 6 or 8 per cent. The summation of heat exposures has usually reached the large total of 59071 hour degree units, with which amount a number of spinose and succulent types start into rapid activity in flower formation and growth. This applies especially to the great sahuaro (*Cereus giganteus*) the flat jointed opuntias and the arboreous forms of the same group as well as to the echinocereuses.

Spinose and Succulent Forms of the Dry Fore-summer:

The succulents comprise two general types, one of which is represented by the cacti with atrophied foliar organs and

storage stems, and the other by the yuccas and agaves with thickened leaves and short stems functioning as reservoirs for the water which was accumulated during the latter part of the winter wet season.

The spinose forms include a wide variety of forms in which the structures resulting from more or less sweeping



Fig. 1. Clump of *Echinocereus fendleri*.

reduction of branches give them a decided spiny or thorny aspect.

Among the succulents, the earliest in the vicinity of Tucson is generally *Echinocereus fendleri*, in which a few brilliant crimson flowers are displayed by the clumps of short, thickened, cylindrical stems late in March, and con-

tinue for a month, to be accompanied and followed by equally noticeable bloom by two or three other small species. Chief of the group, however, is the great sahuaro, the flower buds



Fig. 2. Flowers of *Cereus giganteus*.

of which develop as dense clusters on the portions of the apices of the stems most exposed to the sun, and have been seen as early as March 24th, near Agua Caliente. The



Fig. 3. Symmetrical example of Saguaro (*Cereus giganteus*). Reprinted from Pub. No. 99, Carnegie Institution of Washington.

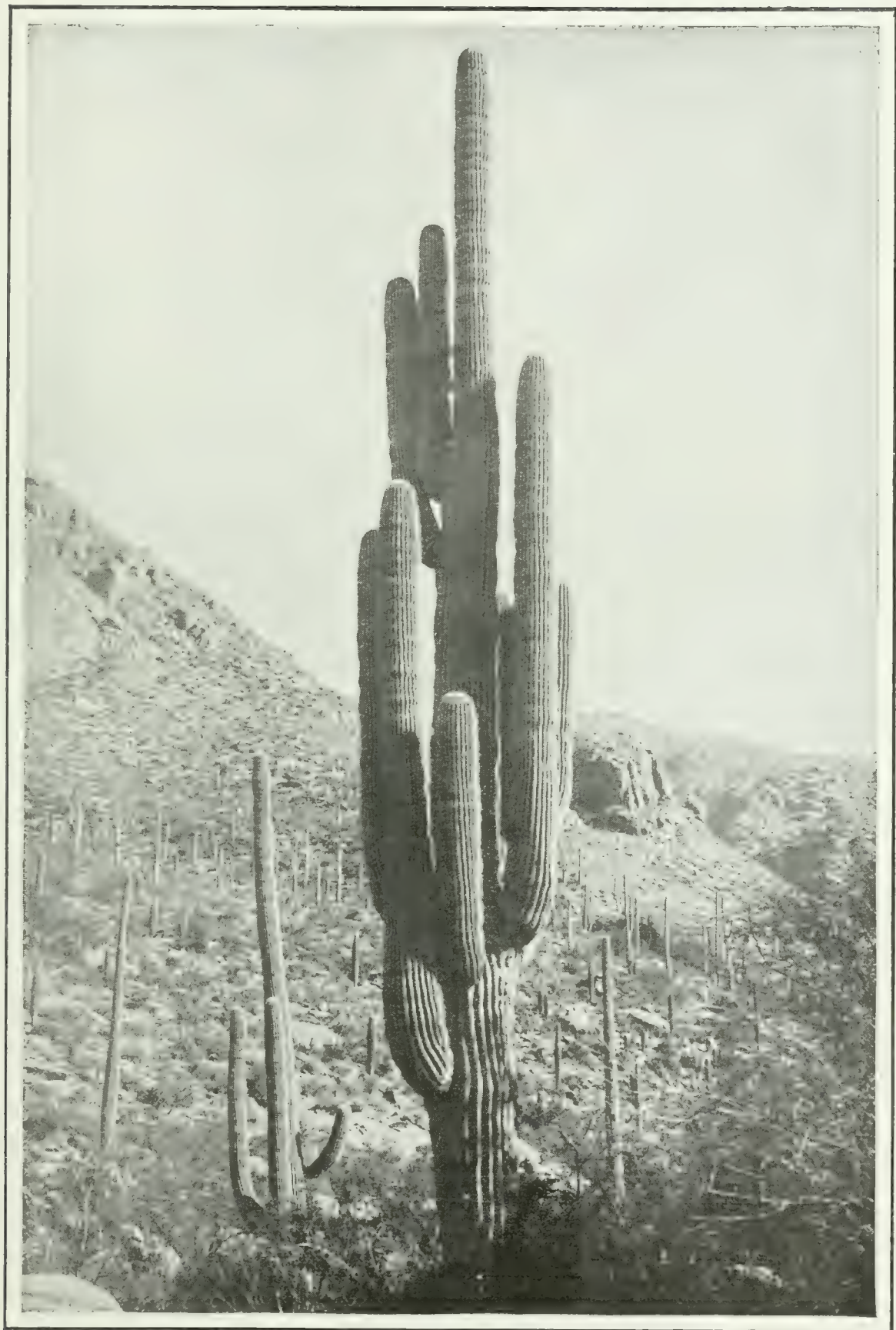


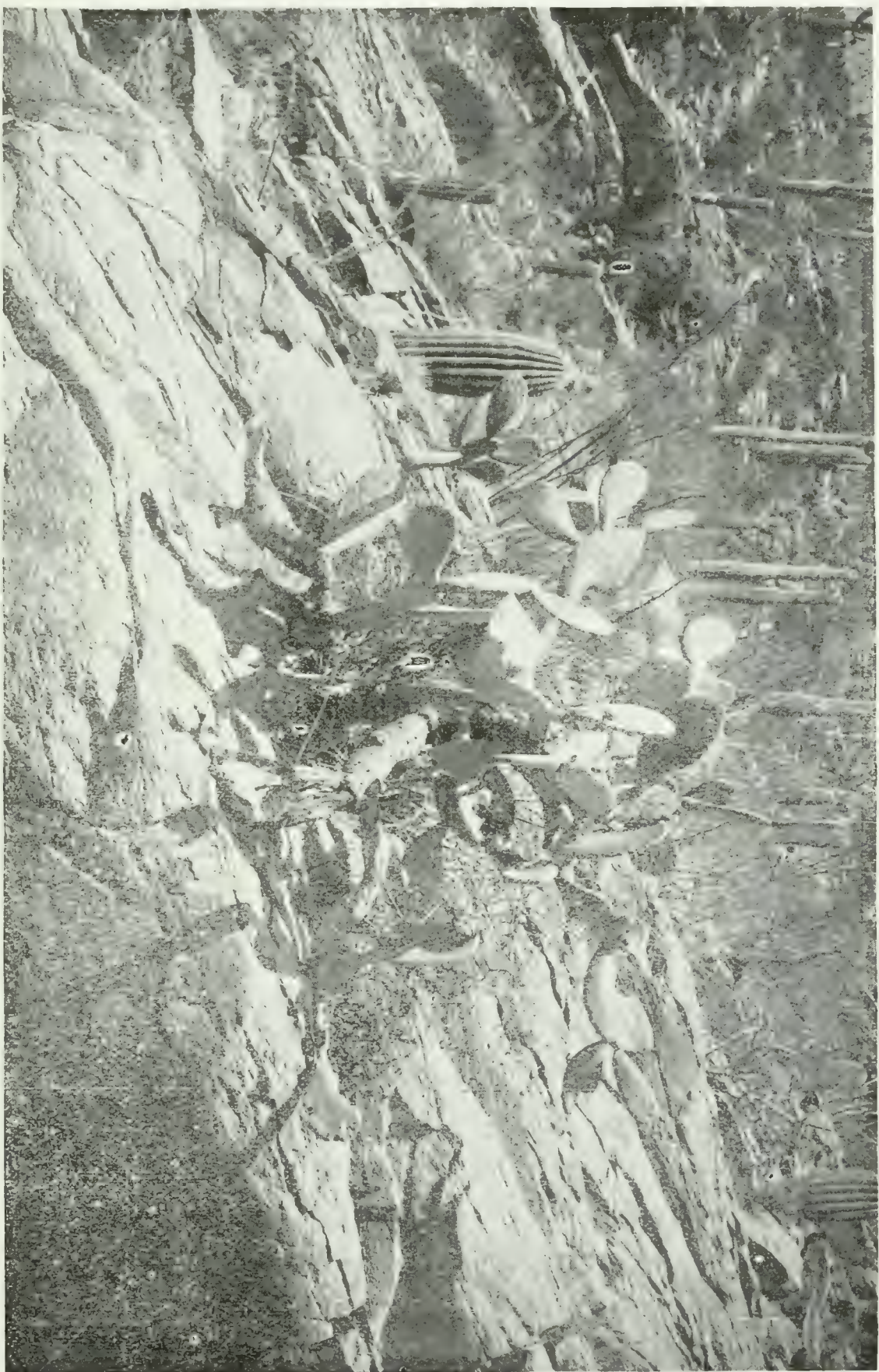
Fig. 4. A form of *Cereus giganteus*, occurring around the Santa Catalina Mountains, Arizona. Reprinted from Pub. No. 99, Carnegie Institution of Washington.

whitish flowers each remain open but a short time and apparently are pollinated by insects. A succession of them ensues, and although practically finished during May or June, yet belated buds open at various times, one having been seen as late as the middle of November. The seedy fruits mature in great quantity in midsummer, and are much prized by the Papagoes, who make much use of them in various ways.

The prickly pears, or opuntias with flat stems, begin to make some growth of new joints and to push out flower buds in March, and late in that month or early in April bloom in great profusion, the fruits maturing early and dropping to the ground. Fifteen or twenty species are native to the Tucson region, but the greatest confusion prevails as to their identity. Of the various desert plants, this group has been the subject of the most inquiry as to its possible economic utilization. After a consideration of the various practical questions connected with open cattle ranges, it has been found that the best use of them for forage is made by growing, or allowing to grow, spinose species, from which the spines are burned when they are to be consumed by animals. This is now done in the open range. Unarmed forms are subject to the attacks of so many animals that it is difficult to bring them to any material growth. A few species are known in which the spines are very sparse. One of these *Opuntia laevis* occurs in the canyons of the Santa Catalina, Santa Rita and Tortolita Mountains chiefly upon rocks or in places inaccessible to grazing animals.

Opuntia chlorotica also has a very few spines, but the circular fronds are furnished with dense bundles of minute spicules or glochids. The highly colored reddish joints and the delicately tinted flowers make this a very attractive plant and it may be found in some of the gardens of Tucson. A half dozen other species are abundant on the mesa-like plains and slopes, two being encountered at elevations as high as 7000 feet in the Santa Catalina mountains.

Fig. 5. *Opuntia laevis*, a semi-spineless prickly pear. Reprinted from Pub. No. 99, Carnegie Institution of Washington.



The rigors of this arid season put the native animals to the utmost test of endurance and many of the rodents have recourse to the supplies of water in the storage stems of the opuntias, eating away whole joints for the mixture of mucilage, water and acid which they contain.

The gardens of older Tucson contain many large specimens of two opuntias native to the tropics or southern Mexico, *Opuntia ficus-indica* and "tuna castilla," both



Fig. 6. *Opuntia chlorotica*, a spineless prickly pear of Southern Arizona.

devoid of spines and cultivated for the sweetish fruits and succulent tender stems.

The cylindrical opuntias include many forms with a central stem and well developed system of branches which give them the form and imposing appearance of trees. These begin activity early in April, two of the earlier ones being



Fig. 7. *Opuntia spinosior*.

O. versicolor and *O. spinosior* (tasajo), with a puzzling range of color in the flowers. Thus, some individuals will be found which have bright crimson or reddish purple flowers and others with light red; others with yellowish red, yellow and greenish yellow, the shade also being reflected by the



Fig. 8. *Opuntia versicolor*: maximum size.

color of the stems, so that the color of the flower may be predicted upon seeing the plant from a long distance. In some instances two colors appear to be exhibited by a single plant, but a closer examination generally shows that what appears to be one plant is, in reality, two grown together at the base.

Fig. 3. *Opuntia fulgida*, and *O. mamillata*, two "chollas" of Southern Arizona. Reprinted from Pub 99, Carnegie Institution of Washington.

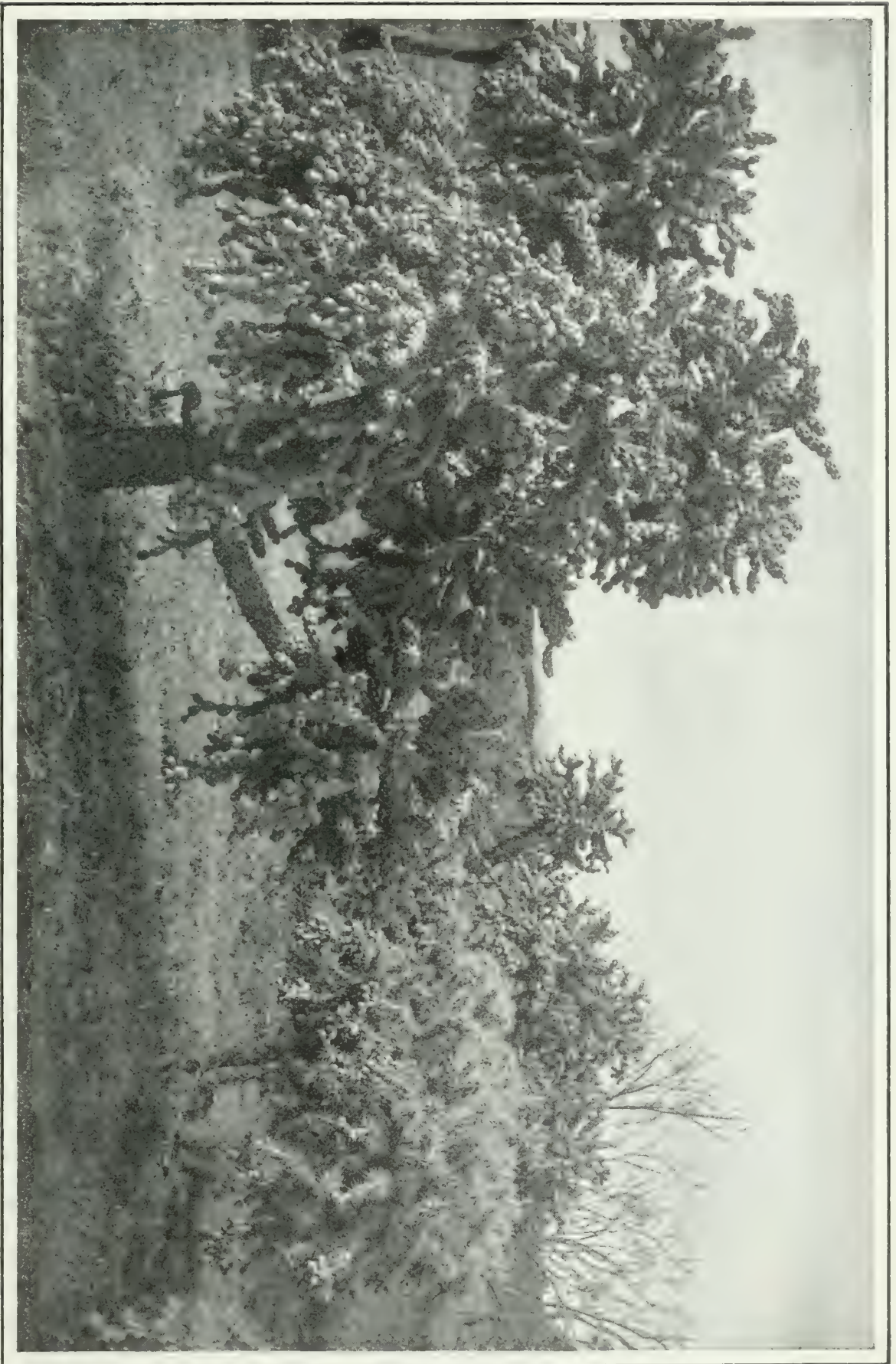




Fig. 10. *Opuntia bigelovii*, the most densely spiny "cholla."

O. fulgida is characterized by the silvery, shiny appearance of the sheaths of the spines, and is locally known as "cholla" although that name properly belongs to a species native to Baja California, much further south. Nearly related to *O. fulgida* and growing intermingled with it is *O. mamillata*, with more greenish branches and shorter and



Fig. 11. *Opuntia arbuscula*.

sparser spines. Both species have easily detachable branches, and the separated portions act as cuttings in propagation. The facility with which the joints are cast loose and attach themselves to an animal by the sharp spines makes them much to be dreaded, and it is by this means that dissemination is effected in a very efficient manner. The fruits remain attached to the branches for several years, and the seeds are exceedingly slow of germination.

Opuntia bigelovii, which is so densely clothed with short silvery spines that a pencil point cannot be thrust against the stem without pushing several aside, is abundant around the mouth of Pima Canyon and shows an extremely wide range over the deserts of the Southwest from Death Valley across to the mesas of Arizona and southward along the shores of the Gulf; it also propagates itself by means of detached joints, and an entire colony of these plants may be seen that have come from one older central individual.

Among the more slender forms of this type, the less common *Opuntia tetracantha* has the size of the chollas, but its thinner reddish stems easily distinguish it from the tasajo, while a second form, *O. arbuscula* makes a low dense clump not above a yard in height, the third species with thin stems being *O. leptocaulis*, in which the diameter is scarcely that of a lead pencil, the entire plant being much smaller than the last named species and quite inconspicuous.

A critical examination of the slender opuntias by Dr. J. N. Rose during numerous field trips in 1908, resulted in the discovery of a species hitherto unrecognized, which because of the profuseness with which it propagates by detached joints has been named *Opuntia vivipara*. Practically all of the space underneath the spreading branches is occupied by plantlets arising from rooting joints, broken off by the wind. The roots of this species display some unusual storage structures.

Several species of birds make their nests in the branches of the cylindrical opuntias, where they are secure from hawks and marauding animals; and many rodents of the desert drag the detached joints about their burrows, making an effectual barricade against the coyote and the fox.

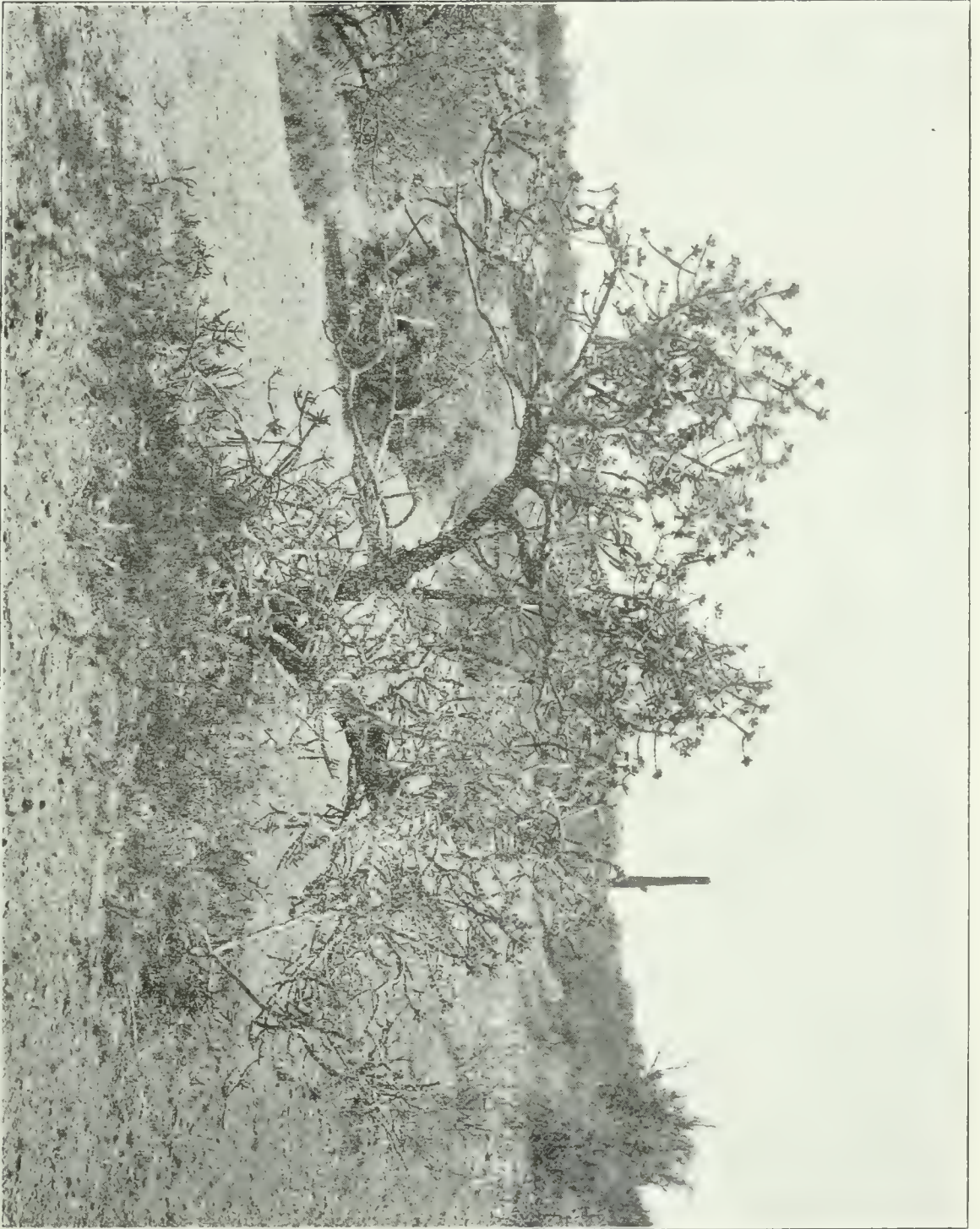


Fig. 12. *Opuntia vivipara*, a newly discovered species.

A REDWOOD SPORT.

By W. A. CANNON.

In a study published a few years since Dr. Peirce* reports the occurrence of white redwood in the Santa Cruz mountains, not far from Stanford University. Peirce's description of the redwood and the conditions under which it was growing, are in part as follows: "The tallest redwood tree in view marks the spot where the white ones grow. This tall tree is one of a number which are several decades old. They, and other smaller young trees of various ages, have come from the stump and roots of a much older tree which must have been very large when it was felled. * * * * There is little left of the old stump above the general ground level. * * * All of these second growth trees are perfectly normal, as far as I could see. One buttress of the old parent tree, instead of sending up a few more or less scattered sprouts which grow up fairly rapidly and, within a season or two take on the characters of young trees in bark, foliage and manner of branching, produces branches or bunches of scrubby, thickly set, short and slender sprouts or suckers. These are perfectly white as to leaves. The youngest parts of the stems are of the same ghostly color as the leaves. These white suckers may attain a height of thirty (30) centimeters in the course of one season." The writer then goes on to say that the suckers grow until the killing autumn frost which they are never able to endure. The white sprouts are in fact annual. Dr. Peirce relates that white redwoods are not especially rare, but that he had not seen another example in the field, although he had, at the time, specimens of such a redwood from near Gilroy.

With the main facts of Peirce's paper in mind, I was much interested, while on a recent botanical trip, to discover a white redwood and to make what field observations on it I was able, since in certain particulars the redwood was differ-

*Proc. Calif. Acad. Sci. 3rd Ser., Botany, vol. 11, 1891.

ent from the one described by Peirce. The locality where I found the redwood sport was the valley through which runs the Big Sur river. It is approximately 36 miles south of Carmel-by-the-sea, and is said to be about 70 miles north of the southern limit of extension of the redwoods. Here the redwoods do not cover the mountain sides and extend to their summits as in the Santa Cruz mountains further north, but are confined to the gulches, or vallies which open on the sea. In such surroundings, which appear to be perfectly congenial to the tree, as on the Big Sur, it occasionally attains large proportions. Such of the large trees as have escaped the woodsman's axe, and their descendants, which form the titantic "fairy rings" characteristic of the redwood forests, make beautiful the precipitous sides of the gulches or banks of the swiftly coursing mountain stream. It was in the midst of such a forest that the white redwood was found. The redwood was a thicket of white, but living, young tree-like sprouts. As the thicket, which was overtopped by towering redwood trees, was examined, it resolved itself into a centrally placed redwood stump, from the base and roots of which sprang suckers. The stump was a large one and from its decayed appearance suggested that the tree must have been felled at least one decade, probably more, ago. The sprouts were about two meters in height and numbered more than eighteen. Each bore short branches of about equal length which were so closely pressed together along the central stem as to give almost the appearance of the "hexenbesen" of common occurrence. The leaves of the present season, which are partly formed only, and those of the past season, together with the twigs of both seasons, were white. The remainder of the plant was brown. The leaves do not survive longer than the second season. From this it will appear that only the tip of the stem, and the ends of the main branches bear the white leaves.

A cursory examination of this ghostly thicket showed that the suckers were of the same age, or nearly of the same

age, that when they first appeared they were probably white, and that subsequently none of them turned green. The immediate cause for the formation of suckers in the redwood is considered by Peirce to be conditions unlike those usually prevailing among the redwoods, as felling, injury of any sort above or below ground, or other considerable disturbance. It is suggested that the white suckers may be the result, not of too little light, but of insufficient warmth for the formation of chlorophyll pigment or chromatophores. When once the shoot appears devoid of the customary green color it remains white, so long as it retains its connection with the mother trunk. In fact, it is a parasite in which the phloem and the xylem of host and parasite are continuous. If, however, the connection with the source of its food supply is cut off so that the need arises for self support, it may have the power to turn green, at least in part. If this is the case it seems probable that, if severed from their food supply, the suckers might as a result of the stimulus of the food requirement turn green, even should the temperature remain too low for them to do so when the stimulus is absent.

Carmel-by-the-Sea, California.

VITAL TENACITY OF AN ORANGE TREE STUMP.

By CHARLES F. SAUNDERS.

The house in which I reside in Pasadena, California, was built just three years ago, on land which was formerly part of an orange grove. In making room for the house a few orange trees were cut down—on what exact date I do not know—but certainly over three years ago. No cellar was dug, but stone foundations two feet high were built, upon which the floor of the house was laid, making a large air-chamber of the aforesaid height beneath the house. This chamber is dark save for a modicum of light which enters by two small cellar windows, and no drop of rain or other water whatever has moistened the ground of this subdomal en-

closure since the removal of the trees, three years or more since.

Nevertheless, in this long unwatered earth, one of the stumps still maintains a vigorous growth of shoots and shows no sign whatever of giving up the fight with aridity. Today I counted sixteen of these shoots, two of which are just putting up, while eight are well supplied with leaves of normal size, the shoots themselves approximating two feet in length. Stems and foliage are all of course quite blanched from growing in the dim light.

The shortest distance from the shoots to the outside of the house is ten feet. There a flower bed receives rain in winter, and some irrigation water during the dry months, but it is difficult to conceive that the influence of such wetting reaches to the old stump. It will be interesting to see how long it can keep up this dry existence.

Pasadena, California, Sept. 13, 1908.

A KEY TO OHIO'S COMMONER CONIFERS.

By L. W. SAUER.

I. Fruitadry, many-scaled cone; a pair of winged seeds in the inner face of each scale. Leaf-buds scaly.

A. Leaves persistent.

1. Needle-like; in clusters. *Pinus* (Pines)

a. In two's,

(1) Cones less than 6 cm., cone-scales tipped—

Yellow Pine *Pinus echinata* Mill

(2.) Cones less than 6 cm., cone-scales not tipped—

Canada Pine *Pinus resinosa* Ait.

b. In three's,

(1) Cones light, but nearly as long as leaves (25-35 cm.)—

Georgia Pine *Pinus palustris* Mill.

(2) Leaves 7-13 cm. cones ovoid—

Pitch Pine *Pinus rigida* Mill.

- c. In five's,
 - White Pine *Pinus strobus* L.
- 2. Linear; scattered.
 - a. Sessile; foursided, *Picea* (Spruces)
 - (1) Twigs glabrous, glaucous; cones droop—
 - White Spruce *Picea canadensis* B. S. P.
 - (2) Twigs pubescent, brown; cones recurve—
 - Black Spruce *Picea Mariana* B. S.P.
 - b. Petioled, flat—
 - Hemlock *Tsuga canadensis* Carr.
 - c. Sessile, obtuse, flat; cones erect, their scales deciduous—
 - Balsam Fir *Abies balsamea* Mill.
- B. Leaves deciduous.
 - 1. Leaves linear, fascicled in spring. *Larix* (Larches)
 - a. Filiform; cones less than 3 cm.—
 - Tamarack *Larix laricina* Koch.
 - b. Flattened; cones more than 3 cm.
 - Larch *Larix europaea* D. C.
- II. Fruit of few scales, 3-12; leaf buds naked.
 - A. Leaves deciduous; cone-scales spiral, thick; root knees.
 - Bald Cypress. . *Taxodium distichum* L. C. Rich.
 - B. Leaves persistent; cone-scales opposite.
 - Leafy branches flat—
 - Arbor Vitæ *Thuja occidentalis* L.
- III. Fruit berry-like, cone-scales united.
 - A. Leaves subulate, prickly-pointed; mid-rib—
 - Juniper *Juniperis communis* L.
 - B. Leaves 2 kinds, subulate and scale-like; no mid-rib—
 - Red Cedar *Juniperus virginiana* L.

University of Cincinnati.

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THE COURSE OF THE VEGETATIVE SEASONS IN SOUTHERN ARIZONA.

(Continued)

By. D. T. MACDOUGAL.

Of the agave, "Spanish bayonet" or "century plants" this region has but few representatives. The slopes and mountain sides between 3000 and 4000 feet bear the rosettes of *Agave palmeri*, which after a period of development varying from a few to many years, sends up a central flower stalk in the foresummer with extraordinary rapidity, growing in length as much as a foot per day and quickly forming flowers and seeds. This effort exhausts the resources and terminates the life of the individual, and the entire cycle of these "century plants" is directed to this one effort of arriving at mature size with an accumulated food supply that will enable them to perfect a crop of fruits and seeds. This habit makes the agaves an important source of food for the southwestern Indians, who take the rosettes when nearly mature and after cutting away the tips of the leaves, bake the central stem and attached leaf-bases for the sugary substances to be obtained, making what is known as mescal. The mescal pits used a decade ago are numerous in the foothills of the mountains in this region, and even yet one may occasionally surprise an Indian feasting upon this prized delicacy.

Growing with Palmer's agave and extending much farther up the mountain sides are great fields of *Agave schottii*, the narrow leaves being no wider than the finger

and less than a foot in length. The plants are thickly crowded in places, and as the upright leaves are sharply pointed an ascent among them is uncomfortable and painful, since the slightest slip on the part of the climber may send a dozen miniature bayonets through the leather of shoes or leggings. Late in May, the inflorescence axis shoots up to the height

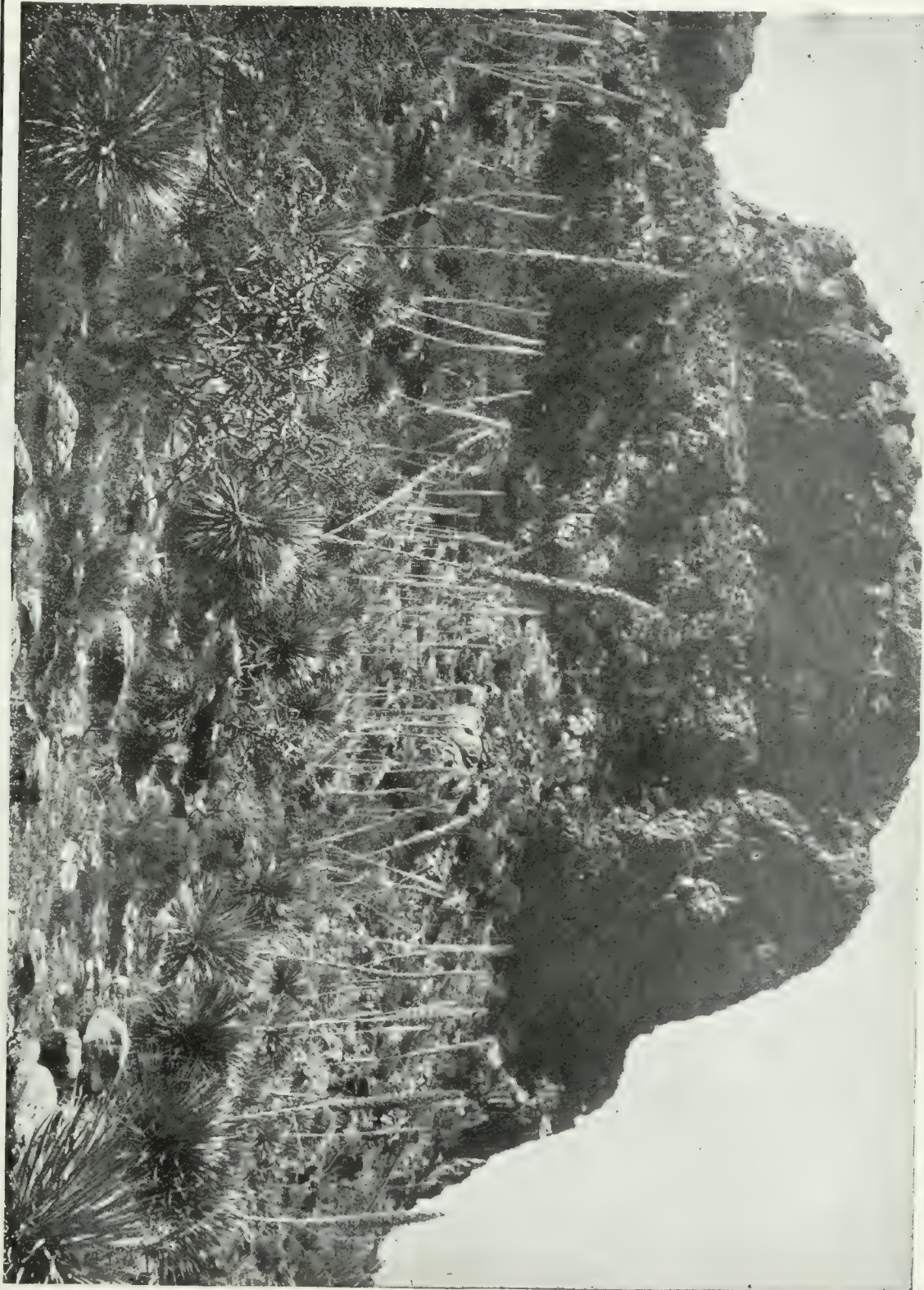


Fig. 1. *Agave schottii* in bloom with ocotillo and oaks.

of a man, the upper half bearing a golden raceme of flowers visible for long distances.

The yuccas and the sotols (*Dasyllirion*) form a great central stem several feet in height with a heavy plume of leaves which may live to a great age. The inflorescence in

Fig. 2. *Dasyllirion wheeleri* in Pima Canyon.



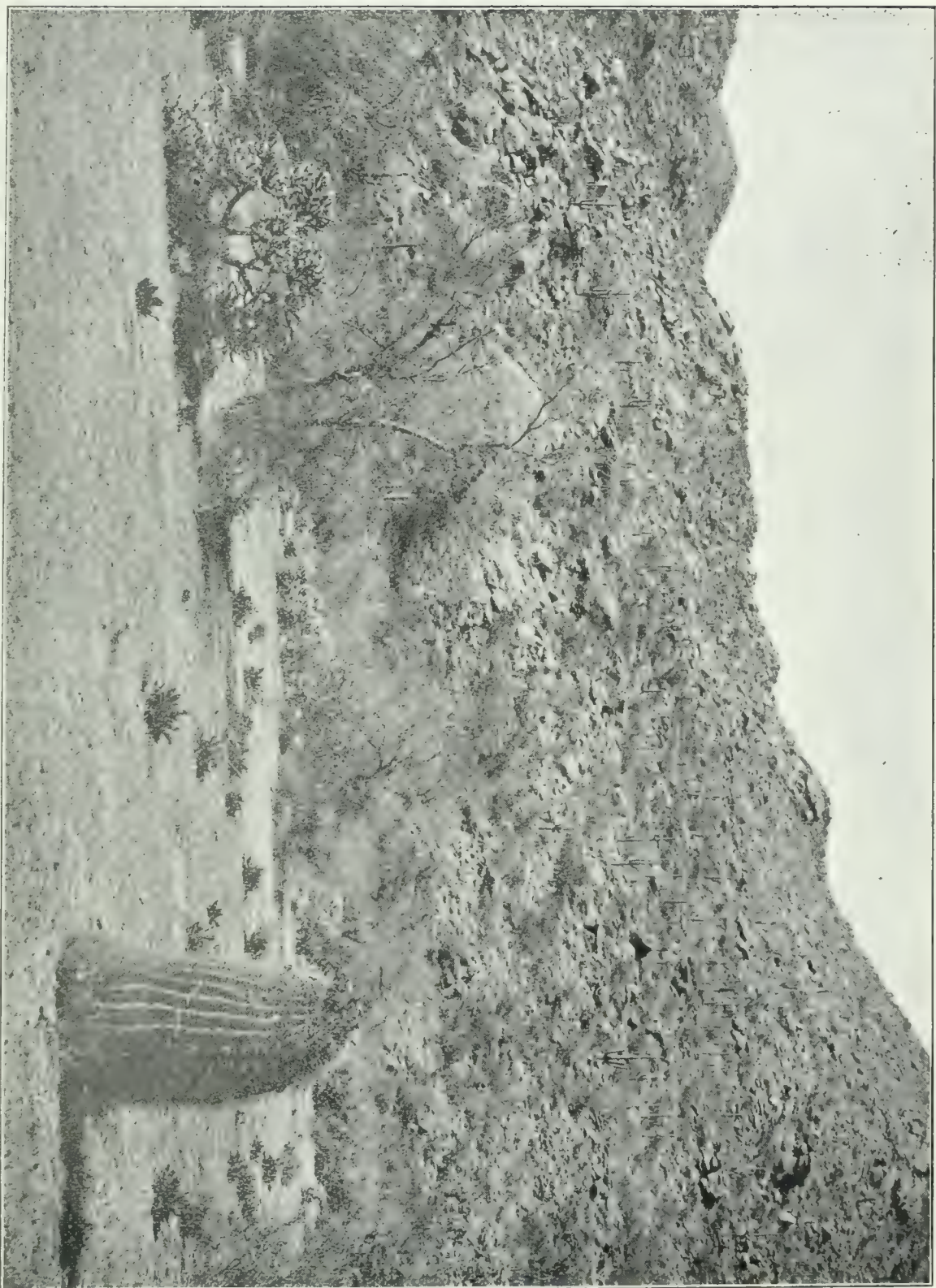
these plants arises some distance from the apex of the stem and the flowering period does not terminate the existence of the individual as in the agave. Sotol (*Dasyllirion wheeleri*) inhabits the rocky canyon slopes a thousand feet above the



Fig. 3. The thistle poppy (*Argemone intermedia*).

level of Tucson although stragglers are found nearer. The short heavy stems and the dense growth of long rapier-like saw-edged leaves make this plant a noticeable one, especially during June when the great shafts bearing numerous delicate

FIG. 4. Floor of canyon in Tortolita mountains, showing canebrake (*Rumex hymenosepalus*), *Lechinocactus*, *Opuntia*, *Parkinsonia*, mesquite and salinaro.



racemes of small flowers are held aloft on the desert slopes, which are held in position for a year, and long after the maturity of the seeds. The location of baking pits above the mescal belt in the Catalina mountains seems to indicate that the Indians have used this plant as food when pressed for supplies. Still a third member of the group is to be seen in *Nolina*, with its dense tufts of linear leaves a yard long among the rocks on the lower slopes, the inflorescences making great irregular cream-colored plumes, visible for long distances on the mountain sides.

Woody herbs and other xerophytes. The yellow of the hillsides of the early part of the year has hardly faded when equally conspicuous clumps of *Riddellia cooperi* begin to show at the same level and globular clusters of this plant endure for several weeks. A number of other compositaceous species of less conspicuous aspect abound.

Of the plants which grow from seed every year, none are more striking than the thistle-poppy (*Argemone intermedia*), which affects sandy slopes and washes, the glistening spiny stems and leaves being a grayish-green, a true desert color. A number of buds are developed and one or more are opened every evening on many branches, so that a display of pure white flowers is offered by an individual for a period of 5 or 6 days.

In the floor-like stretches near the streamways in wide canyons, and over other alluvial areas the canaigre, *Rumex hymenosepalus* sends up its brown spikes from a heavy thickened root which is so heavily loaded with tannin as to make it an object of economic interest. Small ragged irregular clumps of *Krameria* with purplish flowers are found on the hill-slopes, and give the impression of blossoms arising from dead stems.

Not many vines show activity during this season, but the Arizona clematis is fairly abundant in the lower plains and its inconspicuous whitish flowers quickly give way to the glistening silvery tailed fruits which are very showy during June.

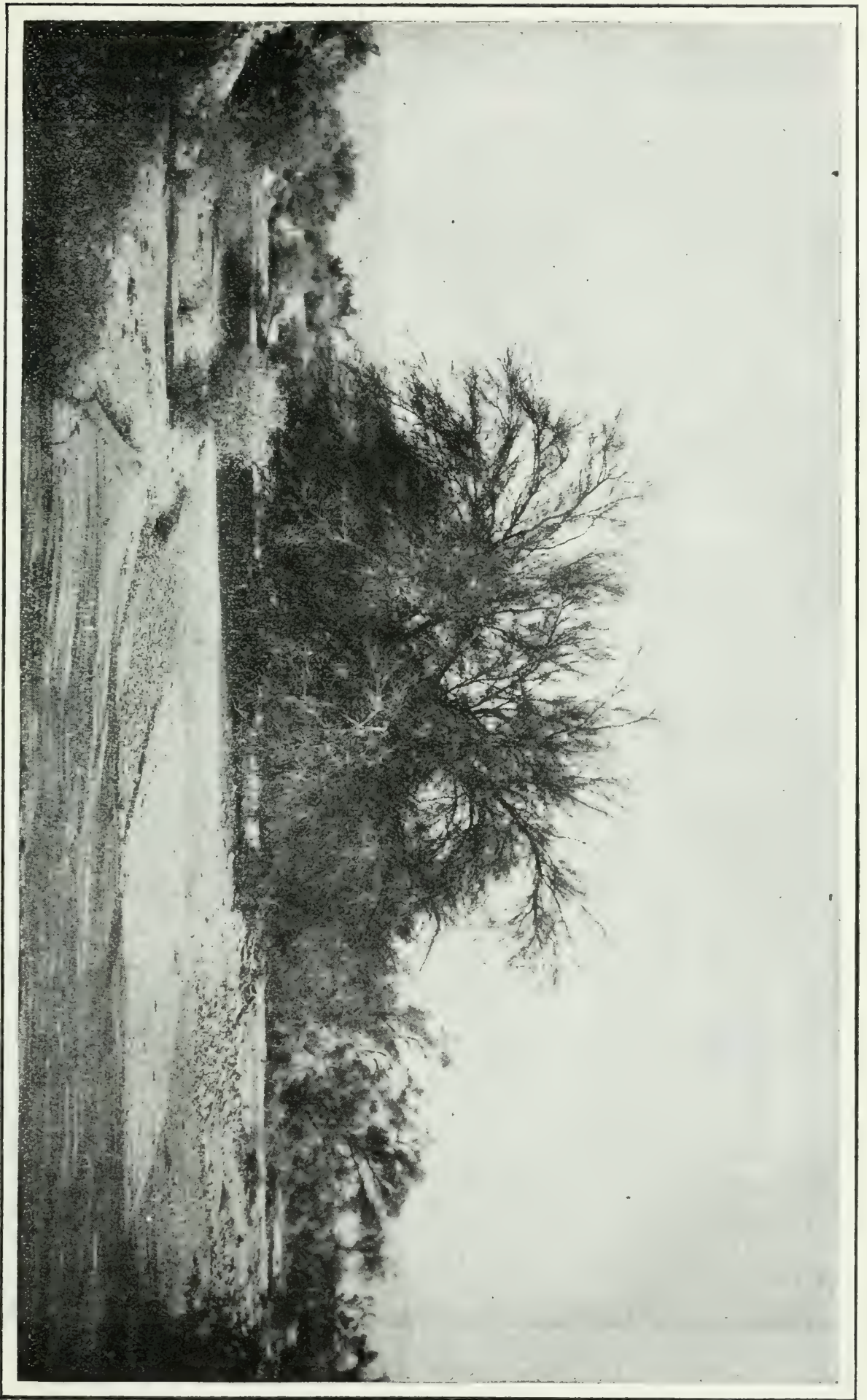


FIG. 5. *Parkinsonia torreyana* growing in shallow wash.



Fig. 6. *Acacia greggii* with mistletoe.

Trees and shrubs. The greater number of trees of the region come into bloom during this period. Of these, *Parkinsonia microphylla* (palo verde) and *P. torreyana* are true desert trees, having very minute leaf-blades which are cast at any time when the water supply fails, and which use the green layers of the bark instead when the leaves are lacking.

The winding sandy course of a dry streamway bordered by palo verdes loaded with golden yellow bloom furnishes a view hardly surpassed in beauty by anything furnished by the southwest. The trees are also sufficiently abundant on some slopes to make the dominant note of color.

Two other pod-forming groups of trees are also active at this time, the acacias and the mesquites. Of *Acacia* there are two species, one with white and the other with yellow flowers, which are sweet-scented and are borne in globular cluster on the small trees. Mesquite attains its greatest growth on the alluvial bottom lands, and it is capable of sending long roots to a great depth in search of water. The delicate green of its leaves is an especial feature. In April and May small racemes of whitish flowers are followed by the pods and bean-like seeds, which are such an important feature in the life of many animals and of the Indians.

Poplars are invariable indicators of the presence of underground water and they mark the streamways wherever an underflow yields a supply during the dry season. Some of the trees along the upper courses of the Santa Cruz and along the Rillito attain enormous proportions of trunk and spread of crown. Singularly enough the same species climbs up a half mile in elevation to follow the water courses into the mountains. A similar extreme range seems to be attributable to the walnut. The walnut of the Tucson region (*Juglans major*) is frequent for the most part in valleys at 3000 and 4000 feet but the tree which grows in some abundance at various places in the Santa Catalina Mts. at elevations of 8000 feet seems to be identical with it, thus giving this species a range of a vertical mile from a sub-tropical to a

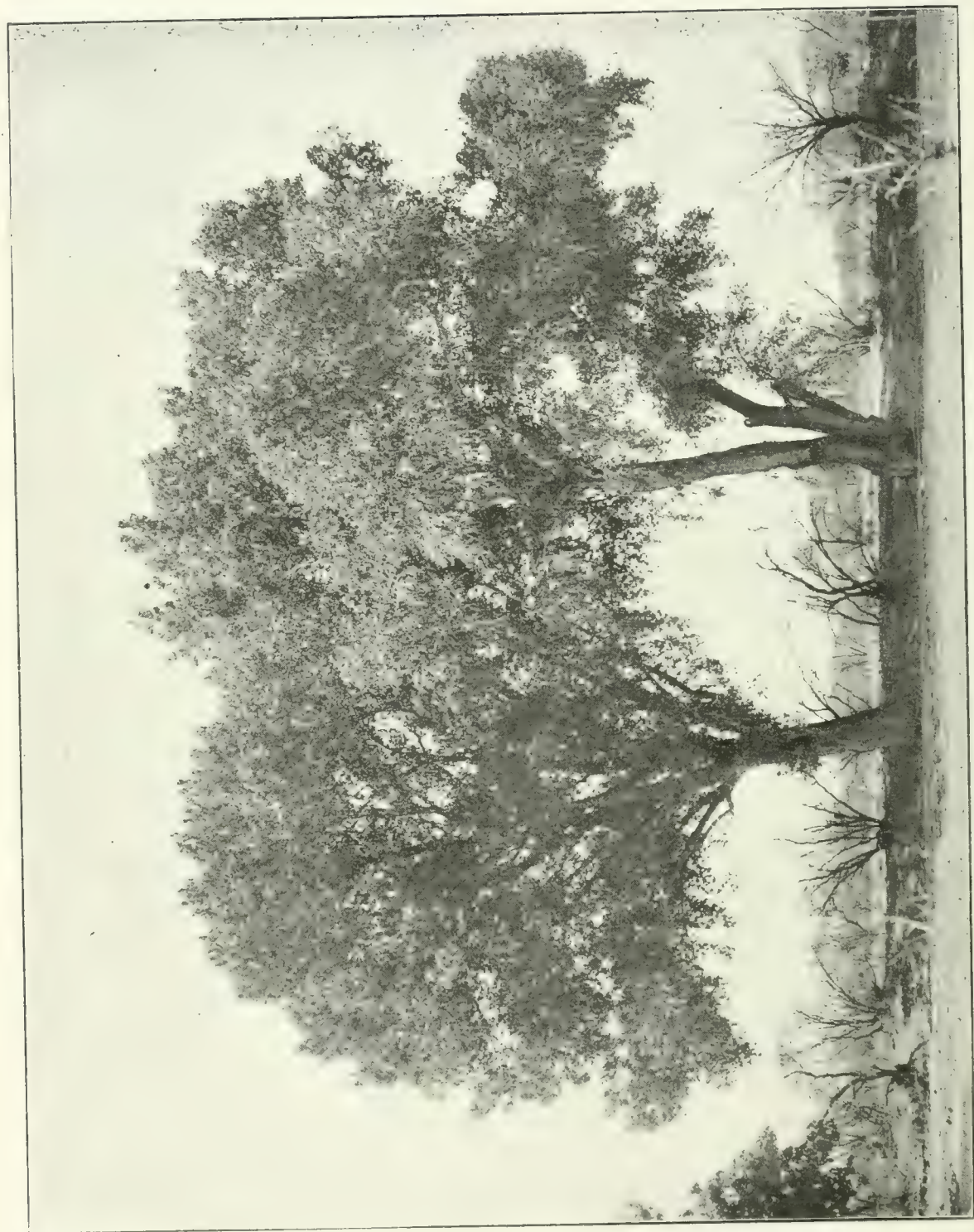


Fig. 7. Poplars along the margin of the Runto Wash.

north temperate climate. A sycamore (*Platanus wrightii*) occurs along streams as they pass through the belt of oaks on the mountain sides. Of these, four species are to be noted: *Quercus emoryi*, the largest of the region forms trees of a height of 75 feet in some instances, with a fine trunk and beautiful spreading crown. The acorns are much in favor with the Indians and Mexicans as food under the name



FIG. 8. Group of *Quercus*, *Nolina* and *Yucca* on limestone slopes.

of "biotas." Scarcely smaller is the white oak *Q. arizonica*, with its oblong or ovate leaves which with the previous species grows above 4000 feet and in company with the pinon of this region which is *Pinus cembroides*, the seeds of which are also eaten by men and animals. Higher on the mountains are encountered the blue oak, *Q. oblongifolia*, the net-veined oak, *Q. reticulata*, the latter being usually a shrub, while still a fourth species, *Q. hypoleuca* occurs around Mt. Lemon.

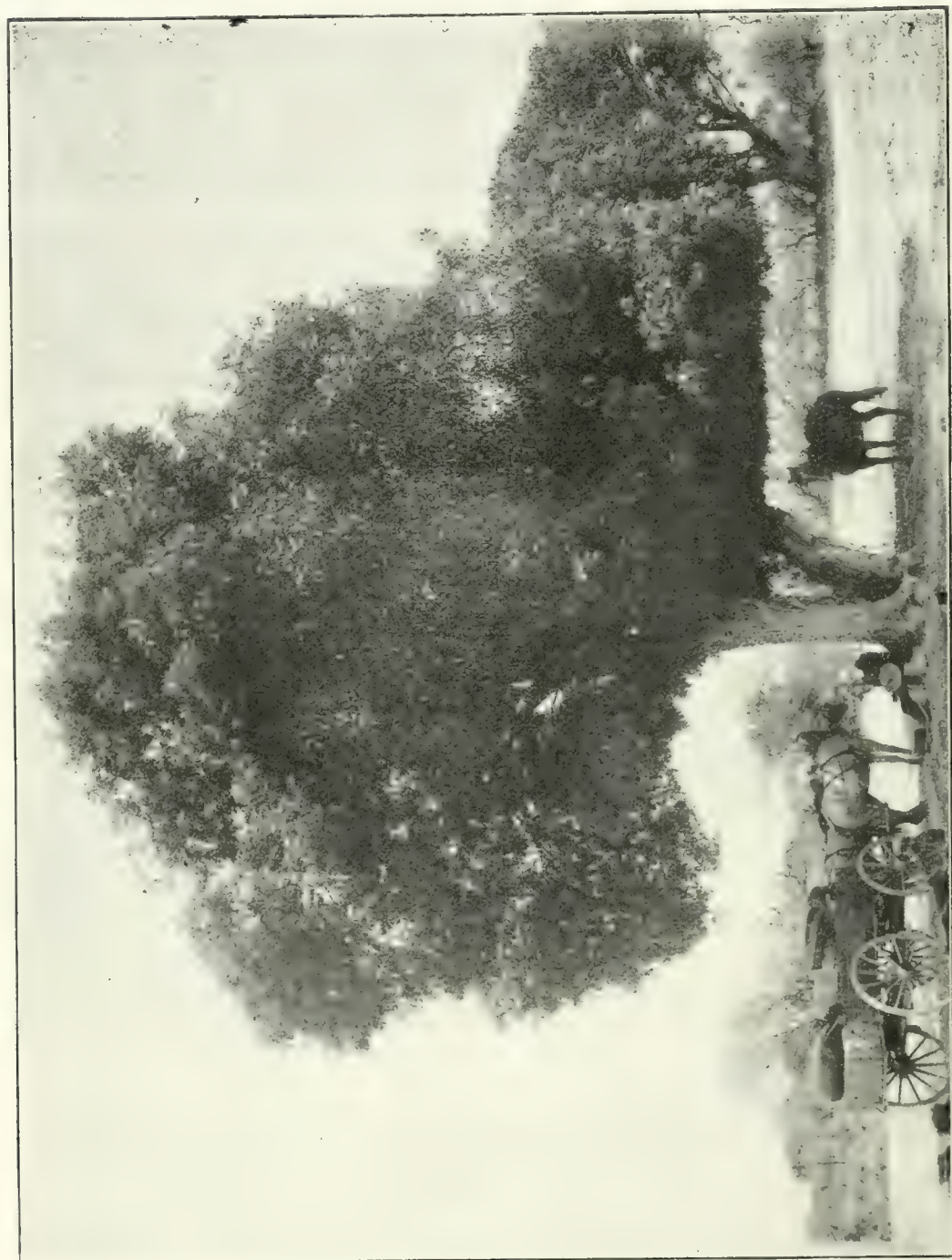


Fig. 9. Arizona ash in middle of Rillito wash.

The Arizona cypress (*Cupressus arizonica*) abounds in the canyons down to the levels of 4000 feet and is successfully cultivated in Tucson and elsewhere. The desert willow (*Chilopsis linearis*) also brings its abundant violet colored flowers to bloom during the season, later ripening a wealth of seed which seem to be capable of wide dissemination. The sanco, or elder (*Sambucus glauca*) becomes a tree with a height of 30 or 40 feet being characterized by the growth of a number of adventitious branches on the lower parts of its grayish trunks. Among the most graceful trees of the region are the ashes, the three species of which show spreading crowns and graceful branches giving the effect of a New England elm. These trees attain notable size along streamways. A hackberry (*Celtis reticulata*) frequents the same regions as the ash, becoming a goodly tree, while a shrubby relative forms dense clumps ten feet in height and of the same diameter on the slopes and plains, being known locally as the garamboya. Three species of *Lycium* open inconspicuous flowers and mature fruits in the summer, both the succulent leaves and fruits being greedily devoured by birds and rodents.

The ocotillo, (*Fouquieria splendens*) displays the terminal racemes of bright flame-colored flowers which tip its diverging branches early in May, and the capsules open to spread the fuzzy winged seeds by the end of the month. Germination quickly ensues producing a stem but 2 or 3 inches in length, which ceases to elongate and lateral branches arise attaining slender divergent lengths up to 6 or even 25 feet, giving the plant a very striking appearance.

WATER CULTURE METHOD FOR EXPERIMENT- ING WITH POTATOES.

By J. J. SKINNER.

In greenhouse and laboratory investigations of some potato soils, conducted by the Bureau of Soils, U. S. Department of Agriculture, water cultures were used quite exten-

sively and were found to be a convenient and very valuable means of investigation.

The young potato plants were procured by sprouting the tubers on a perforated gutta-percha disk, similar to the paraffined galvanized iron wire netting used by Livingston for germinating wheat. * The gutta-percha was closely perforated by means of a drill. It has a hard, stiff surface, floats level upon the water, and does not permit any sagging as do perforated cork sheets and the iron wire netting. The disk was floated upon corks fixed to its edge so that it was held just at the surface of the water in a granite iron pan. If allowed to become submerged the potatoes quickly decay.

Figure 10 shows the method of starting growth. The disk, as shown in the cut, is supported by an iron stand, in order to show the corks and roots. The water in the pan is two to three inches in depth. It must be changed daily. The tubers are cut in small pieces, so that each will include an eye, and placed on the floating disk. Sprouting takes place and definite growth begins within about a week. The roots pass through the holes of the float into the liquid. If good tubers are used the growth is uniform and a large number of plants of the same size can be secured from a single pan. When the plant is about two inches high the potato is removed from the germination apparatus to be used in the water culture test. The young plant with its roots is cut from the mother potato so as to leave no part of the tuber with it.

Figure 10 (below) shows the material necessary in using the potato plant in water culture experiments. The corks used as stoppers are one-half inch in thickness. A vertical wedge is removed, which is truncated at its inner angle, so it can be replaced in position when the seedling is placed in the groove

* The Plant World, 9-1-1906.

from which the wedge is cut. The wedge is held firmly in place by a small rubber band around the circumference of the cork. The bottles are wide mouthed, of low form, hold-



Fig. 10. Method of starting growth and materials used in water cultures of potatoes.

ing about 250 cc. The stoppers fit tightly, which permits no loss of water from the bottles except that transpired by the plants. If desired a record of the transpiration can be

obtained by weighing the bottle and its contents at the beginning and the end of the experiment. *

The method here described was developed in order to make a laboratory investigation of some potato soils. The young potato plants, started as above described, without any part of the tuber for support, were grown in extracts of soils that gave good and poor yields in the field. The extracts were made by shaking or stirring the soil with three times its weight of distilled water and allowed to settle for thirty minutes. At the expiration of that time the solutions were filtered through the Pasteur-Chamberlin filter and put into the culture bottles, details of which are described in the publications of the Bureau of soils, U. S. Department of Agriculture. † The plants grew well in the extracts of the good soil and a number of small potatoes formed. The tops were thrifty and healthy. Figure 11 shows these plants at the end of the experiment.

The seedlings in the poor soil extract made very little growth and did not produce any young potatoes. The extracts in both cases were renewed every fourth day, that is, the old extracts were poured from the bottles and replaced by a fresh supply. This prevents any detrimental effects due to bacterial growth and always keeps a fresh supply of the extract solvents to support the plants. It is not practicable to grow the plants longer than five or six weeks in the water cultures, which is sufficient time to indicate the relative productivity of the soils and to show the effects of treatments.

The method can be used as a means of research in a number of lines of investigation. It is convenient for studying the nutrient or stimulating value of various substances, in connection with plant physiological investigations as well as soil problems. An example to illustrate the nature of the work done and the kind of results obtained is given in figure 12.

* Livingston, B. E., relation of transpiration to the growth of wheat. Bot. Gaz. 40, 178-195.

† Bull. 23, Bu. Soils.

Figure 12 (at right) shows the plants photographed as they grew in the solutions. The bottles are covered with a thick black paper to protect the roots from light. The plants are growing in an extract of



Fig. 11. Potatoes grown in water extract of good soil.

a soil that had grown potatoes for several successive seasons and the yields had become very poor. No. 1 is growing in the untreated extract of the soil. In No. 2 the extract has been evaporated to dryness, the organic matter charred and the residue redissolved in distilled water. No.

3 has the same treatment as No. 2 with the addition of 70 ccm. of NaNO_3 . No. 4 is growing in the untreated extract plus the same amount of NaNO_3 as was added to No. 3. The plants, as seen in the cut, show the stimulating effect of the treatments. The one in the untreated extract made very little growth; it is much smaller than those growing in the treated solutions.

The plants in figure 12 (at left) are the same as those shown in the same figure at the right. This cut shows the difference in the development of roots as well as tops. No.



Fig. 12. Potatoes growing (at right) in solution of poor soil. No. 1, untreated; Nos. 2, 3 and 4, variously treated. At the left the same plants removed from bottles.

2 has the best growth of roots and a healthier appearance. Three bottles are used for each treatment, each serving as a check on the other.

At the conclusion of the experiment the green weight of the plant is taken and the general condition of the tops and roots is noted. These data, together with a photograph, are used as criteria for growth.

GRAY'S NEW MANUAL OF BOTANY.

By J. J. THORNBUR.

Perhaps no book in botany that has appeared during the year will receive greater welcome at the hands of a large and varied group of botanical workers than that of Gray's New Manual of Botany which is just from the press. It is nearly twenty years since the sixth edition of Gray's Manual by Dr. Sereno Watson and Professor J. M. Coulter was published; during this time progress has been extremely rapid along botanical lines the world over. Great changes have been made in classification of plants and in the matter of nomenclature, for which reason the appearance of this classic in American botany is extremely timely.

The authors, Drs. B. L. Robinson and M. L. Fernald, of Harvard University, have spared no pains to make the book as practical for the worker in systematic botany, be he student or amateur, and also as up to date as possible, so far as they felt justified, with reference to classification and especially the debatable subject of nomenclature. The well-known Engler and Prantl system of classification has been followed almost entirely, and as concerns nomenclature the recommendations of the International Congress at Vienna. In deference to differences in nomenclatorial practice existing in this country, where the plant names as given under the International Rules differ from those allowed by the Rochester and American Codes synonyms have been inserted which add greatly to the value and usefulness of the book for the taxonomist. It would seem that in Gray's New Manual we have a book in which there could be a meeting of the minds of practically all American botanical workers, and it is to be greatly hoped that this book will exert a strong influence in settling the controversial subject of nomenclature in this country and in shaping future thought concerning this matter.

As a result of the revisions noted above, the text matter is entirely rearranged and much has been rewritten; besides

numerous changes have been made in the names of plants and in the decapitalization of specific names to conform with modern botanical usage. The ferns, scouring rushes, club mosses and pines are treated of in the beginning of the book by virtue of their taxonomic position, while for a similar reason the sunflower family is placed last. Instead of illustrations appearing in the back of the book as plates, they are now scattered through the work where they cannot fail to be consulted. Families and genera difficult of determination, especially for the beginner, and those which have undergone recent revision at the hands of numerous specialists almost without exception have their critical characters illustrated. Thus we find certain ferns, horsetails, quillworts, also most grasses, sedges, rushes, orchids, willows, oaks, hawthorns, umbellifers and asters among the composites illustrated in their technical and determinative characters. The technique of the work is all that could be asked for.

For valid reasons the territory covered by the book has been extended on the north to include Nova Scotia, New Brunswick and the greater portion of Quebec and Ontario; while on the west the territory between the 96th and 100th meridian has been excluded. The flora treated of is, therefore, more homogeneous than heretofore.

FALL BLOSSOMING OF THE APPLE INDUCED BY THE BLACK ROT.

By H. S. REED.

On October 5th, the writer found normal blossoms on an apple tree in the orchards of the Virginia Experiment Station, at a time when the normal apple trees were shedding their leaves preparatory to entering upon the usual winter rest. The tree upon which the blossoms were observed was of the variety known as Early Ripe and was seriously infested with the black rot of apples (*Sphaeropsis malorum*). The *Sphaeropsis* cankers on the limbs had caused the death of

over half the top of the tree. There were also many branches that, while evidently about to succumb to the injurious effects of the cankers, had been able to make a very small amount of growth during the past season. It was on such branches as these that fruit buds were found open on the above named date. Examination of the blossoms showed that they were normal as regards parts, color and internal relationships. I am informed by Prof. H. L. Price of the Department of Horticulture of this Experiment Station that this fall blossoming is not uncommon on trees which are badly affected by the black rot fungus.

It would appear from the relation of parasite and host that the latter was, in this case, so affected by the fungus that it was unable to bring the growth activities to rest at the close of the growing season. Whatever may be the causes which bring about the periodical rest of perennial plants, the action of the fungus seems, in this case, to have inhibited their activities and allowed the tissues to carry on the growth involved in unfolding, which would normally have been deferred for several months. It is known that treatment with anaesthetics, exposure to low temperature or dessication may materially shorten the normal period of winter buds. * It seems possible that, in some cases, the continuous action of a parasitic fungus, like *Sphaeria malorum*, on the tissues of the host is able to abrogate entirely the winter rest.

BOOKS AND CURRENT LITERATURE.

Camp-fires on Desert and Lava is the title of W. T. Hornaday's last book, published by Charles Scribner's Sons. It details in the author's well known picturesque style the adventures and scientific observations of a party conducted by Dr. D. T. MacDougal on an expedition from Tucson, Arizona, to the Pinacate region in northwestern Mexico. The distance traversed from the starting point to the Gulf of Cal-

* Howard, W. L., Untersuchungen ueber Winterruheperiode der Pflanzen, Dissertation, Halle, 1906.

ifornia is upwards of 150 miles in a straight line, and the longer route necessarily followed leads through a region hitherto unexplored.

The party included a botanist, a geographer, and a zoologist, with the necessary helpers, and a full month was taken for the expedition. The route lay through a region of cactus plains walled in by rugged mountains, past the old Mexican settlement of Sonoyta in the oasis of that name, by dead volcano cones and over rough wastes flanked by peaks formed of molten lava, into the extremely arid country lying east of the head of the Gulf of California.

The scientific results of the expedition include important data regarding distribution in altitude of various desert plants and their habits as the southern limit of their range is approached, observations of the range and habits of various animals, among which should be specifically mentioned the mountain sheep of Mexico, which "represent the end of the great chain of sheep which stretches without a break from * * * the Barbary States of North Africa to its jumping-off place at Pinacate and in Lower California." The excellent maps and photographs and the vivid descriptions of topographical features enable one to obtain a very satisfactory conception of this wild region together with the salient features of its plant and animal life.

Many books have been written about plants by authors who are not botanists, and amateurs in the subject of heredity and evolution have long been prone to air their incomplete information, but if any of this fraternity have produced a book as innocent of any really tenable interpretation of the facts cited as Henslow's "Heredity of Acquired Characters in Plants," it has not come to the notice of the editors of the Plant World. To point out his mistakes in his relation of facts would be to reprint a fair share of the book, and to demonstrate the author's inconsequent reasoning would mean the repetition of his entire thesis. The book in question

arouses some curiosity as to the considerations which lead the publisher, John Murray of London, to send it to press.

Prof. Ewart has lately published a study on the longevity of seeds (Proceedings of the Royal Society, Victoria), in which he corrects many of the earlier incorrect, contradictory or misleading observations on the subject. He made nearly 3000 tests and gives in addition the observations of many previous workers. He finds that the best external physical conditions for longevity of seeds are a cool temperature, and dry, airy storage conditions. In the case of ordinary seeds the drier they are the longer they will last. The longest lived seeds are usually provided with cuticularized, or more or less impermeable coats. However, longevity does not depend on food material or seed coats, but is an hereditary peculiarity inherent in the protoplasm of certain seeds. The length of time that seeds will keep well varies from 36 hours drying outside the fruit (*Cacao*), to 150-250 years, which is the extreme for any known seed.

Seeds which are adapted to longevity show no special adaptation to dispersal. They are, in fact, distributed in time rather than in space. The greatest number of long lived seeds are found among the Leguminosae.

G. von Ihering, after prolonged observation in the vicinity of Rio Janeiro, comes to the conclusion that the species of *Cecropia* there cultivated have "no more need of protecting ants than a dog has of fleas." What has so long been held as a remarkable form of symbiosis he considers to be simply a case of parasitism, since the death of a *Cecropia* inhabited by ants is followed by the death of the colony. A young *Cecropia* which he planted and watched for five years grew into a fine tree and remained entirely free from protecting species of ants. His observations, moreover, go to show that the leaf-cutting ants are not destructive to vegetation, as has been supposed, and that leaf-cutting goes on in

spite of the presence of the alleged "defenders," in short that the whole familiar story of destruction by leaf-cutting ants and protection by other species is to be held as unproven. As Schimper is no longer with us his critic seems for the present to have the field to himself.

Kinzel reports that in his experiments with seeds of *Nigella sativa* germination failed to take place in light at a temperature of 20 degrees (Centigrade?), while in darkness at the same temperature 94 per cent. of the seeds sprouted. At 10 degrees and even 15 degrees germination in light took place, though slowly. Seeds of *Poa pratensis* kept at a temperature of 20 degrees failed altogether in darkness, while in light 95 per cent. germinated.

Arcangeli reports that *Euryale ferox* and *Victoria regia* are physiologically heterospermous, that is seeds of the same fruit germinate at different successive periods. He suggests that this habit tends to the preservation of the species, and that it may occur not only in the seeds of flowering plants, but also the spores of cryptogams and even in pollen grains.

Franceschini in a recent paper enumerates 628 species belonging to 62 families of flowering plants which exhibit some form of cleistogamy. Reviewing the various theories as to its origin, the author concludes that cleistogamy is not a result of mutation, but is a variation induced by external agencies which has gradually become permanent. Tuzson, who has investigated the same subject, has observed two individuals of *Robinia pseudacacia* which produced only cleistogamous flowers. He is disposed to refer the cause in this case to unusually early maturing of the sexual cells.

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THE COURSE OF THE VEGETATIVE SEASONS IN SOUTHERN ARIZONA.

(Concluded)

By D. T. MACDOUGAL.

THE HUMID MID-SUMMER.

The daily maximum registered by the thermometer rises irregularly during June occasionally touching 115° F., relative humidity decreases and the surface layer of the soil becomes heated to a temperature of over 100° F. in the daytime, with but little cooling at night. Thousands of seeds of cacti, hard coated legumes and of grasses are lying quiescent in the soil, which contains too little moisture for swelling and germination. The heat exposure at the beginning of July has now reached a total of 160,539 H-D-F. units, and all of the conditions are favorable for the awakening of hundreds of species which have hitherto shown no activity.

Snowy piles of cumuli begin to be seen on the mountain summits late in June, and the earlier short showers are followed by longer ones which spread out over the plain in fantastic patterns, generally giving the greatest rainfall of the year during July and August. As soon as sufficient precipitation has ensued to bring the soil-moisture up to the critical point, millions of seedlings spring into activity and forty-eight hours may see the entire face of the landscape changed in appearance.

Summer perennials. The great barrel cacti (*Echinocacti*), which have hitherto remained practically dormant,

now having become thoroughly heated up and supplied with water drawn in by the network of roots, which ramify in all directions from the bases of their thick stems immediately underneath the surface of the soil, begin to open a series of reddish and lemon-yellow flowers, to be followed by the formation of a crown of maturing fruits which stay in place until the middle of the following summer. The thick fleshy walls of these fruits have a pleasant acid flavor very refreshing to the wayfarer, while the huge bodies of the plants contain a store of sap readily available for quenching thirst, a discovery that appears to have been made by Indians, in both North and South America. *Mamillaria grahami*, also a cylindrical fleshy cactus, not over a half foot in height, opens its beautiful flowers among the rocks in the foothills at this time and the roster of the bloom of the cacti is completed until the return of another year.

The seeds of the sahuaro, which are produced in enormous quantities, are devoured by the birds before being freed from the fruits, but of the great number that reach the ground and germinate, not more than one in a million survive and make the curious globular plantlet a few inches in height eventually destined to become a great cactus. The seedlings of all of the cacti form a favorite food of a large number of small animals, being juicy reservoirs of water and containing enough other material to lead to their destruction before sufficient armament has been formed for their protection.

Some plants, in the lives of which the supply of moisture is the controlling factor, start up again with the summer rains in a season much warmer than earlier in the year in which they have previously been active. *Cassia covesii* must be reckoned among these, and its brownish pods opening in August make a second liberal sowing of its seeds. *Verbena ciliata* and *Sphaeralcea pedata* likewise respond to the stimulation of increased moisture consequent on the summer rains, but much less profusely, only occasional clumps in bloom

being encountered at this season. A low straggling shrub, the dragon's-blood (locally known as "sangre engrado," as a corruption of sangre de drago), *Jatropha cardiophylla*, spreads its waxy green leaves amid many other plants of a grayer, more xerophytic aspect. The greater part of the yellowish note in the landscape is due to the masses of *Bige-
lovia* of two species with resinous secretions. The pods of the leguminous trees, including the acacias and the mesquites, ripen during this season and offer abundant food to the larger grazing animals.

The purplish salver formed flowers of *Solanum eleagni-
folium*, are seen everywhere in low ground producing small orange colored berries which lie around in great profusion until the following summer before the coat breaks down and the numerous seeds are set free. A relative, *Physalis longi-
folia* is also abundant in the low lands making many whitish and less conspicuous flowers.

Two spinose shrubs, *Koerberlinia spinosa* and *Condalia
spathulata* also make their comparatively inconspicuous flowers and fruits during this season. The long and densely grouped plumose fruits of the Arizona clematis shine silvery gray on bushes and fences, and three perennial vines in addition come into activity, one being a milkweed (*Metastelma
arizonica*) which among other supports is often seen to at-
tach itself to the spiny trunks of the sahuaro. A wild pump-
kin (*Cucurbita digitata*), with narrow spreading divisions to its leaves, spreads over the ground in many places, while a relative, *Apodanthera undulata* is also abundant, the leaves in both cases showing a combination of gray, green and silvery color that betokens the squash family.

Menodora scabra, a small upright plant with narrow leaves and stems also well adapted to the desert displays a number of inconspicuous yellow flowers during the latter part of July, producing an abundant crop of seeds which show a high percentage of viability. Among the various kinds of seedlings that now spring up so densely as to give

a distinctly deeper tinge to the landscape, those of the palo verde (*Parkinsonia microphylla*) are very striking by reason of their number, as well as by the persistence of the cotyledons which increase in size after germination, serving as foliar organs until the first pair of pinnate leaves are well mature.

Summer annuals. Several Euphorbias spread their small dense mats of thin stems and minute leaves on the surface of the ground, and are rich in a latex or *milky juice* containing resins, starch, and some caoutchouc, which is

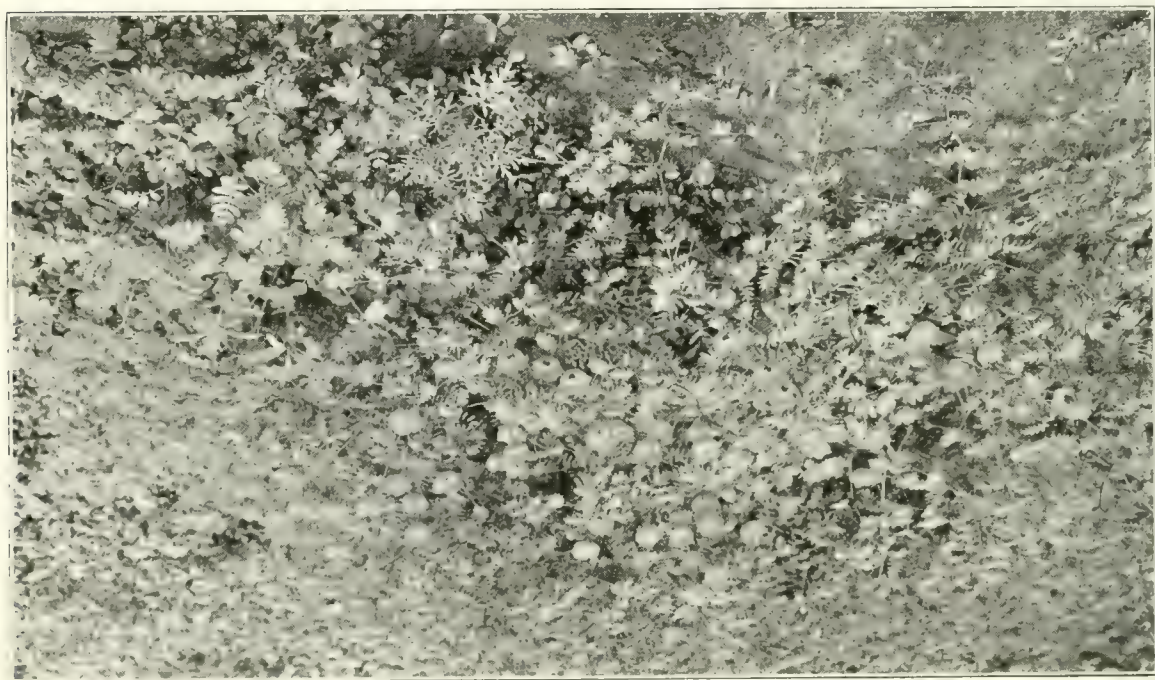


Fig. 1.—*Kallstroemia grandiflora* in midsummer.

reputed by the Indians of various tribes to furnish an antidote for the venom of the rattlesnake, a supposition not confirmed by experimental evidence, however. Another group of species which forms green mats on the surface is comprised within the genus *Tribulus*. Some of the plants of a relative, *Kallstroemia grandiflora*, cover an area of nearly a square yard with a dense mass of green compound leaves offering a background contrasting with the bright yellow and reddish colors of the flowers, which show interesting opening and closing movements. The thin yellowish, almost leafless,

stems of the parasitic *Cuscuta*, or dodder, make a rapid growth during the humid season and quickly twine around the stems and sink their haustoria deep into the bodies of many soft seedlings, although also capable of attacking successfully some forms with an indurated bark or epidermis. During all of this season the humid air, especially after the sudden rains, becomes laden with the pungent odors of the creosote bush and of the various volatile substances produced by many of the desert forms.

Two species of *Martynia*, the unicorn-plant, spring up in great abundance on the mesa-like slopes and in the alluvial bottoms, the showy yellowish flowers being extremely delicate, and enduring but a short time. The bifid stigmas are highly sensitive to the touch, and when the inner surface of either of the two lobes come into contact with any hard object they quickly close together with a trap-like action which would hold an ant or any small insect which might give such a stimulus. The large double fruits are provided with curved spines several inches in length, which readily clasp the foot or hock of an animal and are thus carried long distances, sometimes to the discomfort of the animal to which they become attached. Long fibres are obtained from these fruits by the Papago and Pima Indians which are used in making the dark figures in basketry work.

Two sunflowers (*Helianthus annuus* and *H. petiolaris*) cover great areas in the bottoms, and the yellow disks of the flowers continue to show until well toward September. A small relative of the morning glory, *Evolvulus*, also comes into action at this time, and germinating seeds with the peculiar cotyledons of this family are abundant and widespread.

Wizlicenia *sp.* is abundant in low ground among the mesquites, especially in places where the soil is slightly impregnated with salt or with black alkali. The yellowish racemes or cylindrical clusters of bright yellow flowers are very striking, especially in contrast with the greenness of

the leaves of the mesquite and acacia, near which this plant generally occurs.

Late in the humid season, the fruits of the various prickly pears ripen and develop their hues of red, purple and crimson, the juicy, seedy pulp being most eagerly sought by scores of animals. At times one may see great clusters of the huge "June bug" (*Allorhina mutabilis*) on the pads clustered around a fruit which has reached the proper ripeness. The rapid maturity of these fruits is in striking contrast to those of the cylindrical forms of *Opuntia*, the acid and solid fruits of which often remain attached to the stems for many years, perhaps a decade in some instances.

THE DRY AFTER-SUMMER.

The latter part of the moist mid-summer has witnessed the beginning of growth of a number of grasses of the genera *Triodia*, *Bouteloua* and *Aristida*, which ripen their seeds and persist as tufted bunches of dry haulms and leaves during the rainless season of October and November, being eagerly eaten by grazing animals. During this season an almost total cessation of vegetative activity ensues, and continues until the double stimulation of the moisture of the winter rains and of the increasing heat of the sun after the winter solstice is received. Then the seasonal succession of forms ensues as described, with various modifications due to the wide departures from the normal or average conditions. An example of this diversity is suggested by the records of precipitation, which may vary from 5 to 25 inches per year.

A general view of the entire region shows that it includes as the principal topographical features a series of minor ranges of mountains trending in a northerly and southerly direction, which have undergone tremendous erosion in a desert climate, with the result that the intervening areas are great valleys or bolsons filled with detrital material brought down from the mountains. The soil is very poor in humus, the drainage is undeveloped, oases of peculiar

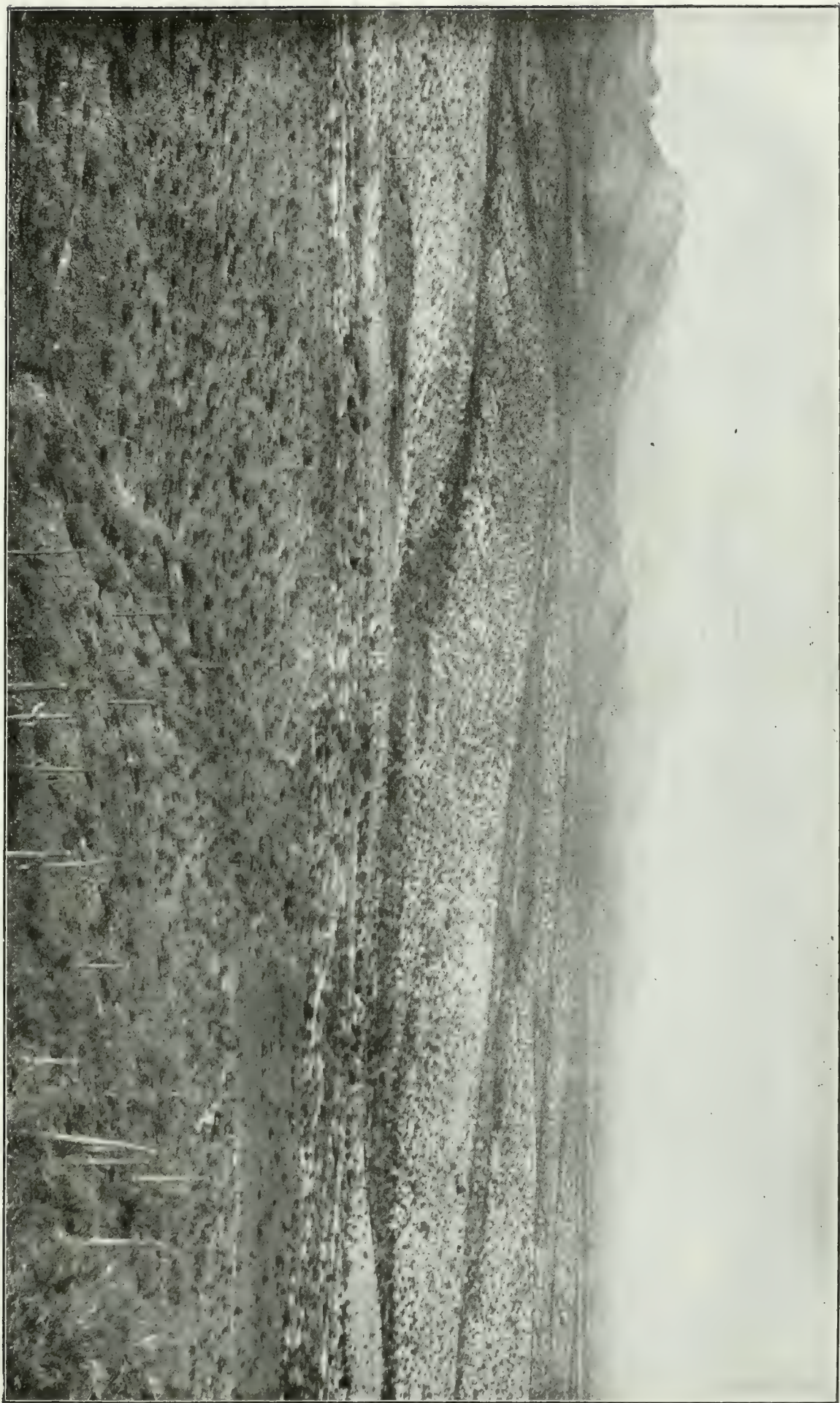


Fig. 2.—Slopes of the Tucson mountains, occupied by a desert flora.

structure occur, the diurnal changes of temperature are of wide amplitude, the effects of wind erosion are very marked, the precipitation sustains a very low ratio to the possible evaporation, as a consequence of which all areas under 4000 to 6000 feet are strongly desert in character. Within the limited areas offered by the higher mountain slopes, much

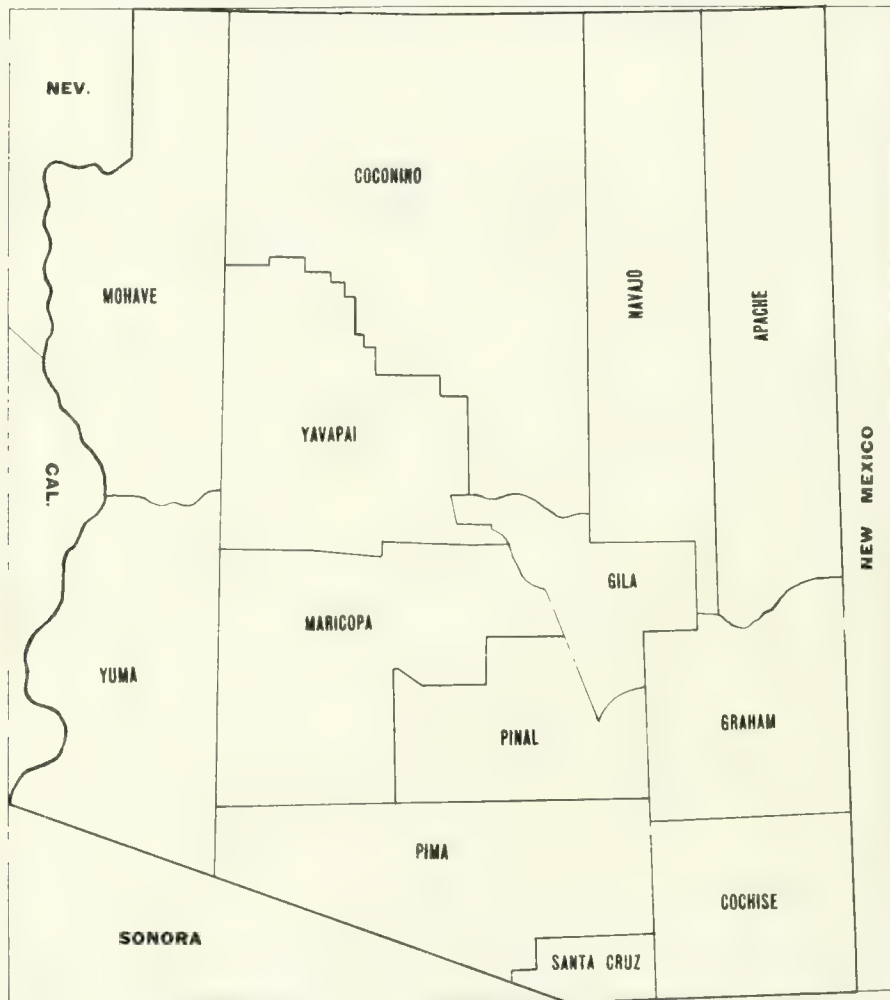


Fig. 3. Map of Arizona. The Desert Laboratory is situated in the eastern part of Pima county.

more mesophytic conditions prevail by reason of the greater precipitation and decreased evaporation. In such comparatively humid localities a vegetation of mesophytic forms is encountered, forming islands in this great desert. Also at lower levels there occur a large number of species which carry out their entire cycle of activity during the brief rainy seasons or periods of greatest precipitation, and these do

not exhibit any marked xerophilous qualities, except that the dormant seeds or quiescent roots are capable of withstanding great periods of drought without damage.

The greater proportion of the area, however, is occupied by true desert species, which by structure and physiological capacity are well equipped for the arid conditions prevalent. In some, structures which prevent loss of water are most noticeable, while in others, the capacity for the absorption and retention of surplus water during times of precipitation is developed to an enormous degree.

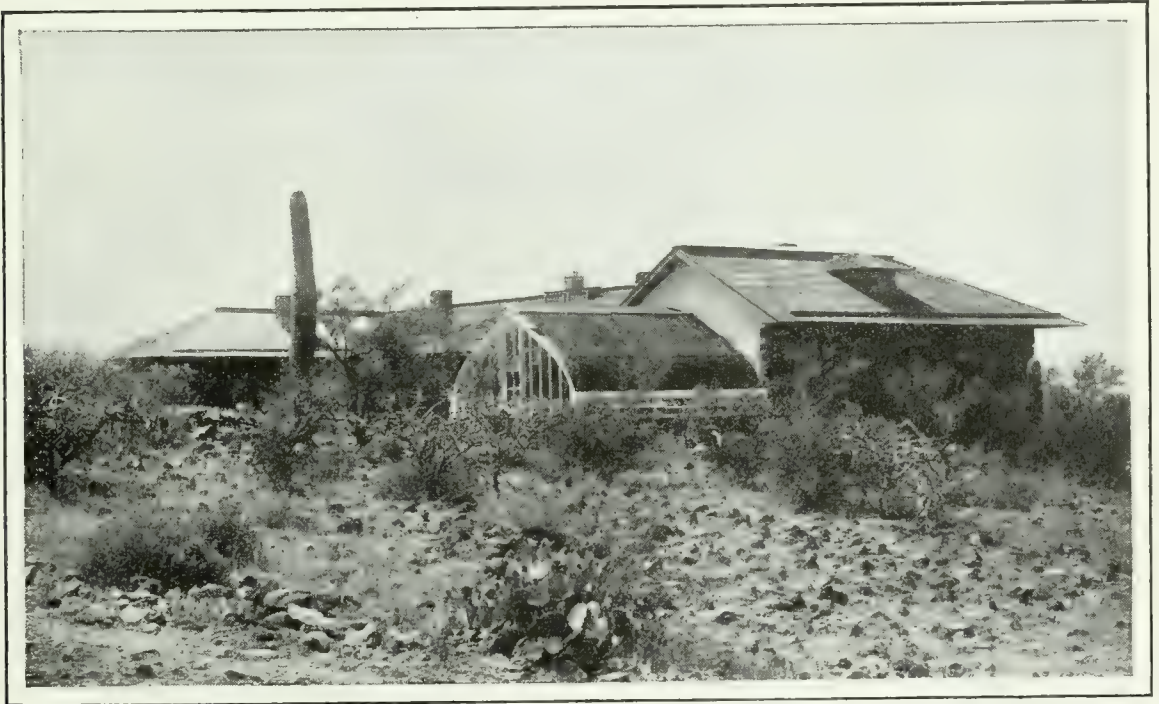


Fig. 4.—The Desert Laboratory, on Tumamoc hill, Tucson mountains surrounded by a vegetation in which winter perennials are an important feature.

A number of species are found over its entire breadth from elevations of 3,000 and 4,000 feet in southeastern Arizona to the dunes near the shore of the Gulf, a distance of 200 miles. Among these are to be included *Cereus giganteus*, *Covillea tridentata*, *Encelia farinosa*, *Prosopis velutina*, *Fouquieria splendens* and *Parkinsonia microphylla*, all of which are essentially desert species, showing marked xerophytic structures. Some of these species extend hundreds of miles north and south of the region under discussion, with

a total range in excess of the variation of conditions which would be furnished by a vertical mile of mountain slopes. Then a large number of other forms occur in very narrowly restricted areas or pockets, evidently determined by local drainage or moisture conditions, so that an analysis of their inter-relations which would make possible a delimitation of "life zones" is extremely difficult. Thus, in traversing the slopes from 4,000 feet in the vicinity of Tucson to sea-level, the only place where any distinct alteration in the character of the flora may be discerned is at the junction of the lava beds with the gravelly detrital plains, and at the contact of the sand dunes with the playas on one hand and with the coastal formations toward the Gulf.

PECULIARITIES IN THE KNOWN DISTRIBUTION OF SOME SPECIES OF CEDAR APPLE.

By R. E. STONE.

In giving the geographical distribution of any particular species we can take into account only those points at which the species has actually been collected. Of course if two collections have been made at no great distance from each other, the probability is that the species will be found between these two points provided physical conditions are uniform. But if the collections were made at widely separated points, the question as to whether the species exists between those points could only be demonstrated by making a careful search for it.

It is a question of the latter sort that prompts me to present this article. The white cedar, *Chamaecyperus thuyoides*, is affected by two kinds of cedar rust somewhat resembling the cedar apple found on the red cedar, *Sabina virginica*. One of these, *Gymnosporangium ellisii*, produces spindle-shaped swellings on the branches of the white cedar. The spore masses protrude through the bark of the affected portion in the form of light yellow or whitish projections

about one-half inch long and as large around as a small nail. The spores when examined with the microscope are seen to be slender with thin walls of a honey yellow color and several septate. The alternate stage of this rust occurs on the Juneberry or Service berry, and is a cluster-cup called a *Roestelia*. It distorts the small branches very much and from the distorted portion the fringed cup-like processes appear. This species has so far been collected only along the Atlantic coast from Massachusetts to New Jersey. On March 3, 1908, while collecting in the vicinity of Mobile, Alabama, I found some very fine specimens of this rust.

The other rust occurring on the white cedar is *Gymnosporangium biseptatum*. This rust occurs on the branches which it causes to swell. The spore masses are flatter and more extended than in *Gymnosporangium ellisii*. The spores when examined with the microscope are seen to be much stouter, darker in color, and seldom contain more than four cells, usually only two or three. The alternate stage of this species also occurs on the Juneberry, *Amelanchier canadense*. Previous collections of this species would seem to show that the rust is confined to the coast swamps from New Jersey northward. On March 3, 1908, I collected a fine specimen of this rust in the swamp between Mobile and Spring Hill, Alabama. Now as these collections very much extend the range of this species it is important to know whether it occurs also along the coast swamp from Massachusetts to Florida and along the Gulf coast. Of course it is possible that the rust secured a foothold in the Mobile section by being carried there by man, but this would seem rather improbable, not only when we consider the nature of the young habitat of the white cedar, but also the nature of the rust itself. It is more than likely that the fungus will be found when the white cedars in the Carolinas, Florida and Virginia are thoroughly examined.

Anyone finding either of these species would contribute greatly to our present knowledge of the distribution of the

species of *Gymnosporangium* by reporting the fact to the writer.

Lincoln, Neb.

BOTANICAL SURVEYS IN NEW ZEALAND.

By FORREST SHREVE.

Two noteworthy papers, the first a report on a botanical survey of the Waipoua Kauri forest, by L. Cockayne, and the second on a botanical survey of the Tongariro National Park, by the same author, have been issued by the New Zealand Department of Lands.*

The Waipoua Forest lies in the extreme north of the North Island of New Zealand at 700 to 1300 feet altitude, and is of considerable economic importance because of the abundance in it of the gum-bearing coniferous tree, Kauri (*Agathis australis*). The gum of the Kauri, the copal of commerce, is derived both from the living trees and from the buried remains of the fallen and fossil individuals. The forest is sub-tropical in character, lying as it does at low elevations in a region of high precipitation where the temperature never drops below 2 to 6 degrees of frost. The Kauri is the largest tree of the forest, towering above the relatively level canopy formed by the other species, but it is not the most abundant of the forest trees. The composition of the forest is varied from spot to spot without relation to environmental factors, and it is also varied as respects the undergrowth and the lianes and epiphytes. Among the commonest trees are species of *Podocarpus*, *Dacrydium*, *Weinmannia*, *Beilschmiedia* and *Metrosideros*, and the sub-tropical element embraces palms, screw-pines, tree-ferns and filmy ferns. Certain groups of trees and shrubs accompany each of the principal forest trees in the localities where they are dominant, thus forming sub-associations within the forest; and the swamps which border the Waipoua river bear a veg-

* Report on a Botanical Survey of the Waipoua Kauri Forest, and Report on a Botanical Survey of the Tongariro National Park, by L. Cockayne, New Zealand Department of Lands, 1908.

etation of distinct character. Small areas in the Waipoua Forest are covered by a heath formation which is much more extensive elsewhere in the North Island. The dominant plants of the heaths are species of *Leptospermum* (Myrtaceae), *Pteridium*, *Gleichenia* and *Lycopodium*, together with a number of shrubs. The heath is not a natural formation, but shows by the presence of gum in its soil that it was formerly occupied by Kauri forest, although the evidences of



Fig. 5.—Scene in the Waipoua Forest. On the right *Beilschmiedia tarairi* (Lauraceae); in the background *Metrosideros robusta* (Myrtaceae), to show the habit of branching. Photo, L. Cockayne.

its active reoccupation at the present day are very slight.

The Tongariro National Park of New Zealand, situated in the central part of the North Island, embraces a variety of natural features such as is found in few areas of its size in any country. The region of the Park rises out of a plateau of 3000 feet altitude and culminates in the three volcanic peaks Ruapehu (9175 ft.), Ngauruhoe (7515 ft.) and Tongariro (6458 ft.), on and about which are active craters, hot springs, glaciers, lakes, bogs, deserts of scoriae and

and untrammelled by strained classifications of vegetation, make these extremely readable papers.

OBSERVATIONS ON HABITS OF FUNGI IN WESTERN PENNSYLVANIA.

By DAVID R. SUMSTINE.

The classification and life-history of fungi has so occupied the attention of mycologists that their ecological relations have been neglected. So many factors enter into the study of these relations that general conclusions can be drawn only after the most extended and exact field observations have been made. Certain facts are apparent even to casual observers, as for example a regular succession of genera and species of fungi from the open to the more dense part of the forest, the connection of certain fungus species with particular kinds of trees, altitude, involving different conditions that influence the distribution of species, and so on; but more definite observations are greatly needed as to seasonal habits, relation to substratum, and associations than have yet been recorded. In view of this the following notes on habits of fungi taken by the writer on collecting trips in western Pennsylvania may be of sufficient value to place on record.

It is noteworthy that many species of fungi endure very low temperatures, and continue their development in the cold winter weather of the northern states. Many of the Pyrenomycetes mature during the winter months in the latitude of Pittsburg. *Collybia velutipes* Curtis has been collected by the writer in January, 1907, growing at the base of a small decaying tree, where much of the time it was covered with snow, but developing sporophores of ordinary size. The mycelium continued to grow during the winter, and a new crop of sporophores appeared in March of the same year. *Pleurotus serotinus* Schrader is found late in the season, usually in October and November. The young plants are often frozen hard during the night, but they grow to ma-

pumice, meadows, scrub, grassland and forest. Cockayne has described the various plant formations lying above the sub-tropical forest at 3000 feet.

The forested parts of the Park lie below 5000 ft., forming large tracts on the western slopes, and scattered ones on the eastern slopes, where the rainfall is not so great. The principal trees are species of *Nothofagus* and *Podocarpus*, the former of which are deciduous. The character of the subordinate trees, shrubs and other vegetation is xerophilous in the main. Altitude is not without its influence on the distribution of vegetation, but the vertical limits of the forest are due to edaphic and not climatic factors, the volcanic soils being coarse and unstable. A shrub steppe forms a transition between the forest and the steppes, occurring between 3600 and 4500 ft., characterised by shrubs belonging to the Australasian family Epacridaceæ, with species of *Podocarpus*, *Dacrydium*, *Veronica*, *Euphrasia* and *Gaultheria*. The grass steppe occupies the same range of altitude as the shrub steppe, and is dominated by the grass *Danthonia raoulii*. The desert areas are very extensive and are clothed mainly with small plants, among which the commonest are members of the genera *Claytonia*, *Veronica*, *Gentiana* and *Luzula*. The cushion plant *Raoulia* is also characteristic of the deserts, and such shrubs as *Dacrydium*, *Olearia*, *Phyllocladus* and *Coriaria*, several of which are most abundant on the desert dunes. In the higher altitudes the shrub steppe often occurs above the grass steppe and sometimes attains to a state approaching that of the forest, the sub-alpine scrub. The bogs of the alpine regions are apparently without peat moss, but include species of *Carex*, *Juncus*, *Utricularia* and *Drosera* in their floras.

Both of the above papers contain numerous observations on structural and organographic features, are well illustrated, and contain lists of the plants of the respective areas. The interesting facts, and the fresh and vigorous style in which they are presented, unburdened by erudite terminology

turity. Some of the *Tricholomas* endure the rigors of early frosts. In the spring, before the frost is out of the ground, *Collybia platphylla* Fries, *Pluteus cervinus* Schaeffer, and *Peziza occidentalis* Schweinitz make their appearance. Species of *Coprinus* were collected this year in the month of March.

Moisture is an important factor in the life of fungi, but many species exhibit considerable power of adjustment and resist continued dry weather. At the same time, copious rains do not always insure large crops of fungi. The rainfall for the months of May, June, and July, 1907, was about the normal, yet fungi were extremely scarce in western Pennsylvania. The old haunts, where in former years it was an easy matter to fill several collecting baskets on a trip, were a barren region. It is not easy to assign a cause for this, but the low temperature during that period may partially explain the scarcity of early summer forms.

It is an interesting fact that in the immediate vicinity of Pittsburg very few of the common species of rusts and smuts are found. After leaving the smoke covered hills and valleys, and arriving in the regions beyond the smoke, they become numerous. It would seem that the fumes from the mills act as a fungicide.

Fungal societies are not so stable and fixed as the societies of higher plants, and it hardly seems expedient at present to attempt a classification on this basis; nevertheless there are edaphic or local associations, which show as evident relations to the substratum as do the associations of flowering plants. Near Kittanning, Pennsylvania, there is a gently sloping hill covered with various deciduous trees. On this hill there appears each year an abundant crop of *Lactarii*. Bushels of these might be gathered. At Ohiopyle, Pennsylvania, around the Park Hotel, situated in an open grove, *Amanitas* grow in profusion. In Allegheny cemetery, Pittsburg, two years ago, a lawn containing several acres was carefully manured in the spring. In the months of August and September of the same year the whole lawn was literally

covered with the *Lepiota americana* Peck. They were so plentiful that the superintendent of the cemetery had them gathered into piles and hauled away in carts. They have appeared now for two seasons. It seems probable that more extended observations of similar facts may result in obtaining a basis for a more comprehensive statement of the edaphic relations of fungi than can now be given.

University of Pittsburg.

BOOKS AND CURRENT LITERATURE.

Floral Succession in the Prairie-Grass Formation of South-eastern South Dakota. By LeRoy Harris Harvey. Botanical Gazette, Vol. 46: Aug., 1908, pp. 81-108; Oct., 1908, pp. 277-298.

The author points to the southern origin of the typical prairie species and the southeastern origin of the mesophytic species found along streams. The total annual rainfall is 24 inches, 83% of which falls from March to September. Low humidity, winter winds and the low winter rainfall are hostile to tree growth, as are also the pre-occupation of the soil, the hostility of the winter conditions for seedlings, and the absence of mycorrhizal fungi from the prairie soils.

The formation studied is made up of some 90 species, belonging chiefly to the Gramineæ, Leguminosæ and Compositæ. The leading feature of the paper is a description of the appearance of the prairie at the different flowering periods in the growing season. These periods, or "aspects," are five, which,—with the number of species flowering in each,—are as follows: Prevernal, April 1-25, 6 spp.; Vernal, May 3-31, 28 spp.; Aestival, June 1-July 7, 21 spp.; Sero-tinal, July 7-Aug. 7, 13 spp.; Autumnal, Aug. 7-Sep. 21, 22 spp. Climatological tables are given for each of the aspects. These show that the soil moisture content varies with the topography in the early summer but becomes uniform in the autumn, which brings about a limited distribution for mem-

bers of the earlier aspects and a uniform distribution for those of the later ones. The members of the successive aspects overtop those of the earlier ones. The slopes facing north are the most mesophytic upland habitats, and on them occur a sod of *Poa pratensis* and the only shrubs of the formation,—*Rhus glabra* and *Symphoricarpos occidentalis*, which are succeeded by *Quercus macrocarpa* and *Ulmus fulva* in the encroachment of the mesophytic element upon that of the prairie.

As the result of an extended investigation conducted in Pfeffer's institute Zehl, L., finds that at a given concentration of poisonous solutions their toxicity is greatly increased with rise of temperature, in most cases finally becoming three-fold what it was at the outset. Germination of spores of *Aspergillus* and *Penicillium* was employed as a test of concentration. Of the few exceptions to the general rule chloroform and ether show a marked falling off in toxic action with increase of temperature.

Schiller, J., who has studied the local distribution of *Ceramium radiculosum* in streams tributary to the Gulf of Triest, has ascertained that this species advances up stream as far as the water becomes brackish at flood-tide and as far down stream as fresh water reaches at ebb-tide. In other words the plant grows where every 24 hours it is twice immersed in fresh, or decidedly freshened water and the same number of times in salt or strongly brackish water. The same factor is potent also in its vertical distribution. It does not live in water containing one and seven tenths per cent. of salt. It attains its best development at a depth of 0.6 m. to 1.2 m., and does not occur at a depth of 2 m., that is its lower vertical limit is reached where very salty layers of water predominate.

Gilg has recently published an extended study of the relationships and distribution of the American species of

Draba. The great variability of species of this genus and the impracticability of depending for their separation on characters commonly employed leads to the conclusion that of some 500 species hitherto described, only about half can be maintained. The genus is held to be of American origin since all its groups that are known in the Old World have more or less numerous representatives in America, while on the other hand there are a number of well marked sections of the genus in the New World which are not represented in Europe and Asia. Furthermore, the different groups in the Old World are quite sharply separated, while in America intermediate forms are frequent; and whereas in Europe the genus is sharply distinguished from all other Cruciferæ, this does not hold true in America. The important fact is brought out that certain variable species widely separated geographically, as for example *Draba magellanica* and *D. hirta*, the latter occurring in high northern latitudes, may present forms growing in ecologically equivalent regions which at first appear identical, but which as a matter of fact belong to different sections of the genus, and are not even closely related.

Hildebrand reports that in the botanical garden of Freiburg seedlings of *Linum perenne* from seeds obtained at Stockholm produced in the first year the characteristic erect fruits of that species; but plants raised from their seeds produced hanging fruits agreeing perfectly with those of *Linum austriacum* and suggesting a possible change from the former into the latter species.

C. E. Moss has compared the distribution of various conifers and dicotyledons, and inclines to the view that the needle leaf and deciduous habit are "due to environmental factors, and may in themselves explain the frequent dominance and successful competition of northern conifers among phylogenetically higher forms."

Lindman considers the sterility of *Carex lasiocarpa* in the peat bogs of Scandinavia and Finland to be due to its unfavorable environment. The lakes and swamps, where it grows under natural conditions, pass gradually into bogs, and here it remains as a relict, the xerophilous leaf structure favoring its continued existence.

According to Mücke the sweet flag, *Acorus calamus*, was introduced into Europe in 1557. It was gathered from a lake in Bithynia and sent to the botanist Matthiola in Prague, and also found its way through Constantinople to Vienna and thence over all Germany.

Patulo concludes from recent studies that the 255 species of the genus *Plantago* have their "centers of origin" in the old world about the Mediterranean and northeastward, and in the western hemisphere in California and Chili.

Professor F. W. Oliver, in a report of progress of a cooperative investigation of salt marsh vegetation in Brittany, gives an interesting account of chromatic instability as observed in *Salicornia* and *Suaeda*. In 1904 and 1905 masses of *Salicornia herbacea* of a crimson color were observed, contrasting with the apple-green individuals in the neighborhood. In 1906 the plants on the same ground were of mixed and intermediate colors; but in 1907 there was again, though in less marked degree, a differentiation of shades. The purple and green *Suaeda* showed similar changes. Transference of soil from one patch to another had no apparent influence on change of color.

Gius states that as the result of submersion in water seedlings of *Vicia sativa*, *Phalaris canariensis* and some other species exhibit heliotropic curvature later and curve more slowly than in the air. He concludes that the reaction is hindered by reason of the influence of the surrounding

medium by which the difference of turgor on opposite sides of the seedling is interfered with.

Ostenfeld's experiments with seeds of *Potamogeton natans* which had been voided by swans show that their germination is promoted and hastened by their passage through the digestive tract of these birds. He holds the view, however, that the efficiency of birds as distributors of seeds to long distances has been overrated and points out the necessity of more definite experimental evidence in this direction.

NEWS AND NOTES.

Prof. Francis E. Lloyd has taken up his duties as head of the Department of Botany in the Alabama Polytechnic Institute, Auburn, Ala. During the past fifteen months he has been engaged, in co-operation with Professor Whittelsay, of Northwestern University, and Dr. J. E. Kirkwood, late of Syracuse University, in the study of the desert rubber-producing plant, guayule (*Parthenium argentatum* A. Gray). These gentlemen constituted the personnel of the Department of Investigation of the Continental-Mexican Rubber Company. The Department was recently discontinued as a result of a change of policy on the part of the Company.

Prof. A. S. Hitchcock, Agrostologist of the Department of Agriculture, spent two days in Tucson on his return from the Pacific coast, where he has been engaged in field work since June. Professor Hitchcock has been collecting grasses in all the higher mountain ranges of California and Oregon, and made ascent of Mt. Whitney and Mt. Shasta. He will visit several localities in northern Mexico before returning to Washington.

Mr. Joseph H. Painter, assistant in the United States National Herbarium, was drowned in the rapids of the Potomac, December 6, 1908, near the headquarters of the Washington Biologists' Field Club of which he was a mem-

ber. Every evidence tends to show that he lost his life in the vain endeavor to rescue a boy friend, R. S. Wallis, who was unable to swim. The Field Club has assisted every effort and used every incentive to recover the bodies, and has adopted the following memorial:

Resolved, that the Washington Biologists' Field Club has suffered a profound loss in the death of Mr. Joseph H. Painter; that the Club has the highest admiration and respect for the noble character and heroic sacrifice for a younger companion which appears to have led to Mr. Painter's untimely end; that the Club extends its sincerest sympathy to the bereaved relatives.

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